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The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but the publication of contributions is not to be construed as official approval of the views expressed.

ECONOMIES IN PRINTING.

Contributions intended for publication in the REVIEW must in all cases conform to the regulations of the Department of Agriculture with respect to effecting economies in the public printing. The following memorandum in regard to preparing manuscripts for publication has just been issued by the Department.

It is reproduced below for the information of all concerned.

Authors will be expected to prepare their manuscripts, with the understanding that once the manuscript leaves the author's hands it is in final form and not subject to further changes of text in galley or page proof. With the adoption of this policy it will be necessary that authors consult workers on related subjects in other Bureaus before finally submitting their manuscript for publication, and all matters as to which there is difference of opinion must be settled in advance.

BACK NUMBERS OF THE REVIEW WANTED.

The Weather Bureau has not enough of the following numbers of the MONTHLY WEATHER REVIEW to meet even urgent requests for filling up files at institutions where the REVIEW is constantly being referred to. The return of any of these or of any 1919 or 1920 issues, especially November, 1919, will be greatly appreciated. An addressed franked slip may be had on application to the Chief, U. S. Weather Bureau, Washington, D. C.

1914: January, February, March, April, September, October, December.
1915: May, June, July, August.
1916: January, August.
1917: June.
1918: February, September.
1919: Any issue, especially November.
1920: Any issue, especially January.

SUPPLEMENT, No. 3.

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

VOL. 49, No. 10. W. B. No. 758. OCTOBER, 1921. CLOSED DEC. 3, 1921. ISSUED JAN. 31, 1922.

RAINFALL MAPS OF LATIN AMERICA.

By EUGENE VAN CLEEF.

[Chicago, Ill., May 11, 1921.]

INTRODUCTION.

The accompanying rainfall maps were prepared originally in wall-map size as a part of the work of the Latin American Division of the House Inquiry, New York City, June-December, 1918. The study was made in the building of the American Geographical Society, where this society's splendid library of books and maps was readily available.

The sources of data were numerous, though the data were limited. The various libraries in New York City were consulted. In some instances data were gathered from private libraries of corporations. Individuals who had visited portions of the regions were called upon to to contribute what data they might have gathered and to give of their experiences and observations. The Government libraries in Washington, D. C., were referred to, and many men in the Government scientific departments gave generous aid—both data and criticism of the maps. The circumstances, therefore, under which these maps were constructed were highly favorable. In fact, it would be difficult to reproduce them, excepting under some such urgency as was brought about by the Great War.

The first two questions requiring careful consideration were: (1) On what type of base map should the data be plotted, and (2) how should the data be treated? The first question was the more easily answered. A new hypsometric map of Latin America was in course of preparation which it was planned to use. Unfortunately, work did not progress on this as rapidly as hoped for, and therefore the base of the South America map in the Goode Series was put into service.[1] Maps of Mexico and Central America were adapted from Mexican Government maps.

The second question, relating to data, presented a number of problems. Data for most of the areas are scarce and, with few exceptions, not wholly reliable. The records for most stations are of short term. Furthermore, they are not always for corresponding periods and hence not always comparable. While the data ought to be reduced to a common base, their irregularity in so many respects made this impractical, and so it was decided to plot them without modification, but in the drawing of the isohyets to use the greatest caution, bearing in mind these inaccuracies. Consequently, the drawing of these isohyets resolved itself largely into a matter of interpretation.

Figures alone could not suffice where interpretation plays so large a part. The distribution of the highlands and lowlands, the prevailing winds, the drainage systems, were given considerable weight. Where data on humidity and evaporation were available consideration was given them. The nature and distribution of the vegetation and character of soil were oftentimes used as determining factors. In other words, every piece of evidence that might shed some light on the probable course of the isohyet was brought into play.

It is not supposed that these maps[2] are in any way a final statement of the distribution of rainfall in Latin America. It may require another 75 years or longer before we have enough accumulated data to produce an accurate map. These maps are only intended to serve as a slight contribution to the slowly accumulating knowledge about our neighbors to the south.

In the following paragraphs a brief account is presented descriptive of the rainfall distribution. One of the interesting problems in the determination of this distribution is described as illustrative of numerous problems still to be solved.

RAINFALL IN MEXICO.

The distribution of rainfall in Mexico is controlled by the northeast trades and the extension of the great Hawaiian and Azores high-pressure areas over North America during the winter season, coupled with the presence of north-south mountain ranges of considerable elevation.

In the winter season the high pressure over North America results in a shift of the winds from northeasterly to northerly. These winds, blowing over the continental mass of the United States and northern Mexico, are relatively dry, and hence result in bringing about only minor quantities of rainfall. Occasionally the winds blow from other directions, but at no time are they sufficiently marked to increase the rainfall notably at any given point. As summer approaches, the pressure breaks down over the northern part of North America, and the northeast trades become well defined. As they blow across the warm waters of the Caribbean Sea and the Gulf of Mexico, much moisture is carried inland upon the highlands of Mexico. The result, of course, is fairly heavy precipitation. The seasonal shifting of the winds is quite regular, hence the variation in amount of rainfall

[1] This series of maps is published by Rand McNally & Co., Chicago, who very kindly permitted the use of the base.

[2] The isohyets of Central America, although drawn in full lines, should be considered, at best, as close approximations only. The same may be said of the isohyets for South America, except for certain parts of the South Temperate Zone. Mention should be made of a very recent contribution upon the rainfall of Chile by Prof. Mark Jefferson, *American Geographical Society Research Series*, No. 7, New York, 1921. This publication has appeared since the manuscript of the above article was received.—EDITOR.

is quite as well clearly marked. In the case of Chihuahua, in northwestern Mexico, the increase from almost nothing during the first half of the year to some 200 mm. during July is noteworthy. This, however, is a pure case of the influence of highlands upon precipitation and local wind conditions. It probably also is affected by the low-pressure areas common in this part of the continent, which carry in a considerable amount of moisture from the Gulf of Mexico. To be sure, it is an indirect process, but nevertheless it is effective. Just what rôle cyclones and anticyclones play in affecting the climatic conditions of northern Mexico is not well understood because of the lack of observations. It seems, however, that this must have a strong influence, in view of the effects in Texas and the other bordering States of the United States.

Records for brief periods of time indicate prevailing winds for scattered points as coming from directions other than those which one would expect in a system of shifting northeast trades. This inclines one to the belief that too much emphasis has been placed upon the influence of northeast trade winds in Mexico, and insufficient upon the likelihood of cyclonic and anticyclonic influences referred to above.

Three characteristic winds along the Pacific coast influence the distribution of rainfall. They have special names. The northers, when sufficiently strong to blow across the plateau lands into the more southwesterly parts of Mexico, and accompanied by clear weather, are called *Papagayos*. Southwest winds, resulting in a rainy season during the summer time, are known as *Temporales*. At the beginning and the ending of the rainy season, well defined thunderstorms of considerable proportions, seemingly coming out of the east, are called *Chubascos*.

RAINFALL IN CENTRAL AMERICA AND PANAMA.

The northeast trades on the Atlantic coast, and the southwesterly winds of the Pacific coast, the latter sometimes said to be a new direction of the southeast trades as they cross the Equator, are the controlling factors in the distribution of rainfall. However, it is essential to call attention to the fact that these winds do not always reach over the land, but are occasionally supplanted by a local circulation which brings about an effect wholly different from that which might be expected from the popularly better-known winds. The trades of the Atlantic coast and the southwesterlies of the Pacific coast are fairly constant over the water bodies. The general conditions for the west coast and the east coast follow.

The west coast.—Along the west coast the dry season occurs from January to March. This is the season of the *papagayos*, or easterly gales. Only occasionally do light showers fall. The season is truly dry. In general, the weather from December to March is quite delightful when the north to northeast winds have effectively counteracted the influence of the southwesterlies, which might be said, in popular terms, to have been driven away from the coast. This dry period is followed by a rainy season called the *Invierno*. This rainy period increases in severity until about June, when it reaches its climax, and is followed in a month or two by a relatively dry season known as the *Veranillo de San Juan*. There again follows an increase in precipitation, not so great as that of the first maximum, after which there is a decided reduction in rainfall or, in other words, a return to the dry season of the first part of the winter. Most of the rainfall occurs in the form of thunderstorms and, therefore, may be said to be an afternoon phenomenon. These thunderstorms are daily and occur with almost clocklike regularity.

East coast.—In contrast with the west coast, there is no real dry season along the east coast, although the curves for stations along the east coast would seem to show a distinct dry season. The dry season, however, is only relative, that is, it rains less at one time of the year than at another. There are two such depressions during the year: One in the springtime, and one, much shorter and less well marked, in the late summer and early fall. During the northeast trades from October to about January, the rains are almost continuous. A second rainy season occurs from June to August. The first relatively dry season occurs from February to April, while the one less well marked makes its appearance rather uncertainly during a late summer or early fall month, such as August, September, or early October.

The division of the year into two rainy periods and two dry periods is not only characteristic of the territory extending from southern Mexico to Colombia in South America, but is equally true for practically all of the West Indies.

RAINFALL IN SOUTH AMERICA.

The distribution of rainfall in South America is a factor of the distribution of highlands, lowlands, and water bodies, versus atmospheric circulation. The shifting of wind systems produces a variation in the amount of precipitation in the several regions of South America, as noted in detail below:

The rainfall areas of South America impress one with their symmetry, corresponding to that of the distribution of highlands and lowlands.

South America may be readily divided into certain rainfall provinces:

(1) A wet northwest Pacific slope.
(2) A dry central Pacific slope.
(3) A wet south Pacific slope.
(4) A wet northern interior.
(5) An intermediate southeast interior and coastal region.
(6) A local Brazilian highland dry region.

These six areas may be defined roughly as follows:

(1) The slope of the Andes, extending from the Isthmus of Panama to latitude 4° south.

(2) The western slope of the Andes, from latitude 4° south to 36° south. This zone extends over the crest of the Andes in latitude above 30° south, and continues along the eastern slope through Patagonia to the Atlantic coast,

(3) Latitude 35° south to Cape Horn.

(4) Essentially the Amazon River Basin.

(5) The Gran Chaco, Paraguay, Uruguay, northern Argentine region.

(6) Three islands of diminished precipitation in the States of Ceara, Rio Grande Do Norte and in extreme northwestern Bahia, extending across the Rio Sao Francisco into Pernambuco as shown on the chart of annual precipitation.[3]

It is perhaps worth while to note the characteristics of the shifting winds as affecting the increase or decrease of rainfall in these regions. The heavy rainfall in region (1) is due to the prevailing southerly to southwesterly winds, occurring during essentially each month of the

[3] The author's rainfall maps, with his consent, were submitted to Director Sampaio Ferraz of the new Brazilian Meteorological Service, during his recent visit to the central office of the Weather Bureau. Director Ferraz volunteered to supply data for northeastern Brazil, evidently not available to the author. These data have been furnished and the isohyets of the original chart of annual rainfall have been modified accordingly. The charts of winter and summer precipitation are, however, as presented by the author.—EDITOR.

October, 1921. M. W. R.

October, 1921. M. W. R.

ATLANTIC OCEAN
GULF OF MEXICO
CARIBBEAN SEA
PACIFIC OCEAN
COLOMBIA
VENEZUELA
BRITISH GUIANA
DUTCH GUIANA
FRENCH GUIANA
ECUADOR
PERU
BRAZIL
BOLIVIA
PARAGUAY
URUGUAY
CHILE
ARGENTINA
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
JAMAICA
NICARAGUA
COSTA RICA
LATIN AMERICA
(THE TIMES ATLAS - LONDON, 1920.)
SCALE OF MILES
0 100 200 300 400 500 600
H.B.

year, due to the probable influence of the permanent South Pacific high-pressure area and a strong sea breeze. These southwesterly winds, blowing across the Pacific upon a highland slope, are diverted upward and depleted of their moisture as their temperature is lowered. It should be noted here that the influence of the South Pacific HIGH is dominant immediately along the west coast of South America, because of the cold currents in the ocean. These currents cause a considerable difference in temperature between the air over the water and that over the coast, giving rise to a landward movement of the air. The rainfall in region (2) is strikingly small; in fact, the region is a desert. Along this part of the coast, the winds from the South Pacific HIGH parallel the coast, producing essentially no effect upon it, while the prevailing southeasterly trades lose their moisture as they rise over the crest of the Andes and descend on the Pacific slope. These winds, descending from great heights, become evaporating rather than precipitating winds, and so intensify the aridity of the coastal strip over which they blow. This statement holds true as far south as latitude 30° to 32°. Beyond this latitude, where the desert area laps over into Patagonia, the belt of prevailing westerlies is encountered. As these winds pass over the Andes and descend the eastern slope, they play the same rôle which the southeasterlies played above. In region (3) the prevailing westerlies blowing from the Pacific are heavily laden with moisture. As they rise over the slopes of the Andes their moisture is condensed, resulting in heavy precipitation upon the windward coast. In region (4) the doldrums control the situation. These winds, consisting of warm, rising air; precipitate their moisture in the area over which they rise when reaching high altitudes. Since the air currents are essentially all vertical, and the temperatures at the surface are relatively high, the alternating processes of evaporation and precipitation result in a heavy rainfall for the entire basin. The area, which is rather extensive, is influenced by the southeast and northeast trades, respectively, as the wind belts shift southward and northward. As a consequence, on the outer borders of the doldrums there are two rainy seasons. In the region of the Guianas, the doldrums are effective in June.[4] At the same time, the southeasterly trades have moved northward to approximately the latitude of the Equator and increased the amount of precipitation over the southern Brazil and northern Paraguay. As the doldrums shift southward during the next six months, a short dry period intervenes in the Guianas, followed by another wet period due to the more southerly extension of the northeasterly trades. During this same period, the southeast trades have moved farther southward, resulting in a dry season for southern Brazil and northern Paraguay. The next year the process is repeated. Throughout the entire year, however, the doldrums are effective in the immediate vicinity of the Equator and east of the Andes highlands, causing only a slight variation in the amount of rainfall, a little more between the Equator and about 8° north during June, a little less between the Equator and about 8° south during the following December.

In region (5), where the rainfall is intermediate, the principal factor is the southeasterly trades. There results an alternating dry-and-wet period, the dry period occurring in December when the southeasterly trades are farther south, and the wet period in June when they are farthest north.[4] The flatness of the land permits these winds to penetrate far inland and distribute their moisture rather evenly instead of in concentrated form at any particular point, with a possible exception of limited areas along the coast in the latitude 23½° south. The explanation for the semiarid regions in northeastern Brazil (6), is not available. Theories have been offered, but are not sufficiently well founded to warrant their acceptance.

[4] June and December are mentioned as representative of winter and summer seasons, respectively.

THE PROBLEM OF THE LLANOS OF COLOMBIA AND VENEZUELA.

Exact data for the region are not available. Descriptions by a few explorers of sections of the territory give some light. The most striking feature, which to date has had no satisfactory explanation, is the treeless character of the interstream area. These regions are occupied by tall grasses, mostly succulent, while the banks of the numerous rivers which drain the land are lined with a dense forested growth. Away from the rivers the vegetation occasionally shows xerophytic characteristics.[5]

In the absence of figures the distribution of precipitation throughout the year can only be described more or less hypothetically. The year is characterized by two seasons, a wet and a dry, with the dry season perhaps slightly longer than the wet. The rainfall during the dry season ranges perhaps from 50 to 250 millimeters and for the wet season from 250 to 500 millimeters, totaling for the year in the neighborhood of 1,000 to 1,200 mm. The last figures include the rain of the transition months from wet to dry and dry to wet. This distribution in itself might account for the nature of the vegetation. On the other hand, excessive porosity of the soil could constitute the dominant factor in the development of the same floral scene. The absence of trees could hardly be credited to native infertility of the soil. The soil should be highly fertile, since it is derived largely from the Cordillera Oriental, an igneous highland.

It is possible that the paucity of trees is the response to a combination of highly porous soils and an extended dry season.[6] Hettner describes the absence of trees in the upper Magdalena to the high porosity of soils. Since the soils of the llanos must have somewhat similar origin, it becomes quite possible their porosity plays a significant part.

The dry season is sufficiently long, evidently, to make the vegetation dry enough for burning, for the area is burned over quite frequently. If ever there were trees, the burning over annually would in itself soon prove a permanent check to tree growth. The removal of the forest might induce an increased rate of evaporation and therefore tend to check precipitation locally. Burning also reduces the soil fertility after the succeeding third or fourth years when the soil becomes decidedly acid.[7]

The absence of trees, then, may or may not be an index of low precipitation or even of a long drought period. Precipitation might be of very appreciable quantities even during the dry season and yet allow of

[5] The general description here given is derived primarily from the following sources:
Bingham, H.: Journal of an expedition across Venezuela and Colombia, 1906–7. New Haven, 1909.
Hettner, A.: Die Kordillere von Bogota: *Petermann's Mitteilungen*, Ergänzungsheft XXII, 1892.
Rice, Hamilton: *Geog. Jour.*, vol. XXI, pp. 401–418, 1903; vol. XXXV, pp. 682–700, 1910; vol. XLIV, pp. 137–168, 1914.
Chapman, Frank M.: The distribution of plant life in Colombia: *Am. Mus. Natl. Hist. Bull.* XXXVI, 1917.

[6] See note 1, *supra*.

[7] The question of soil acidity resulting from burning over, is still considered unsettled in the United States. In northern and northwestern Germany where burning over has been the customary spring or fall practice, the Government (in 1913) prohibited it. The results of investigation by agricultural experiment stations show that the fertility is increased for only from 1 to 3 or 4 years, after which a period of 25 years must elapse before the original fertility returns.

burning. Only a few weeks of dry weather, with the sun well in the zenith, and hence its rays essentially vertical, are sufficient to make the grasses dry enough for ready combustion. In northeastern Minnesota, where the annual precipitation is about the same as that in the llanos, namely, 750 to 1,000 mm., the rainy season occurs during the summer months, with a primary maximum in June and secondary maximum in September. Yet during late October and November forest and prairie fires are not uncommon. It is true that the pine trees invite fire, but the grasses are probably as succulent as those of the llanos and even these burn readily after a short dry season.

The vegetation of the llanos, therefore, throws little light on the amount of rainfall, and the amount of rainfall so far as it is known does not in itself seem to account for the vegetation. For the present, and until observations through a series of years become available, the assumption remains that the rainfall of the dry season is due to the moisture carried inland by the northeast trades, encouraged as it were, to penetrate so considerable a distance, by the trough formed between the Cordillera Oriental and the Guiana highlands, combined with local excessive heating which induces a lower pressure than that existing to the northeastward of the area. The wet season results from a northerly extension of the doldrums during June, July, and August. These, however, are probably not so effective as farther south, owing to the intensity of local convection, which may be sufficient to carry moisture to elevations of over 15,000 feet where strong westerly winds of the upper air circulation can carry the water vapor away before condensation is accomplished.

No mention is made in the literature, of a local mountain wind from the Cordillera Oriental corresponding to the chinook of North America or the bora of the Adriatic. It seems possible that a local wind resulting from differences in temperature between the crests of mountains and the plains below might develop during the doldrum period, when convection is strong over the plains. An accumulation of cold air on the mountains in sufficient masses could gain large momentum moving down the rather steep slopes and develop into evaporating winds of consequence. This would tend to counteract some of the precipitation which normally should fall in quantity under the doldrum influence. Further exploration of the area might reveal the presence of such winds.

The question, then, of the cause of the apparent dryness of the llanos and the absence of trees in interstream areas must remain in the hypothetical stage. The statements here offered are presented as suggestions and possible bases for further inquiry.

SOME ILLUSTRATIVE TYPES OF LATIN-AMERICAN RAINFALL.[1]

By BERNARD O. WEITZ.

[Washington, D. C., Nov. 15, 1921.]

SYNOPSIS.

The following is a discussion of a few graphs showing the monthly distribution of rainfall at selected stations in Latin America. These have been grouped as follows:

1. Mexico, Central America, and the West Indies.
2. Western coast of South America (3 sections).
3. Northeastern South America and the basin of the Amazon.
4. Eastern South America, Brazil, Argentina, Paraguay, and Uruguay.

INTRODUCTION.

The accompanying graphs were prepared to supplement Van Cleef's rainfall maps published in this REVIEW. It is of interest to note the effects of the precipitation controls of Latin America, not only on the annual and seasonal distribution of rainfall, but also the precipitation from month to month.

Twenty-five representative stations[2] were selected, embracing the various types of rainfall found throughout the region. The effects of prevailing winds, shifting wind belts, mountains, and ocean currents is to produce a diversity of rainfall types. When we correlate the geographic coordinates of various localities with the climatic controls mentioned above, the explanation of the different types usually becomes apparent. The characteristic distribution and climatic factors affecting these types are discussed.

Mexico, Central America, and the West Indies.—Over this entire area the most important of the precipitation controls is the northeast trade, with its characteristic winter maximum on windward coasts and mountains. The southern part, however, especially the leeward shores (cf. Panama), is subject to the midsummer convectional rains accompanying the northern position of the heat equator belt of calms (doldrums).

In most of Mexico the annual minimum comes during the winter and early spring, the region being too far south to be affected much by the southern extensions of strong extra-tropical LOWS. The maximum comes late in summer, the moisture for these convectional rains coming from the Gulf of Mexico. Mexican rainfall may be described as the marginal tropical type, the trade-belt rains being affected[3] by the migration of the equatorial rain belt with the northward and southward movement of the sun. During this time the trades seem to strike the windward coast from a more easterly direction than during the winter, when they blow from the northeast and have a drying influence.

In the West Indies the principal control is the northeast trade. Owing to the east-west trend of the mountains in Cuba, Santo Domingo, and Porto Rico, the northern and eastern coasts are much moister than the southern coasts, and the monthly distribution on the windward side of the mountains is also more equable than on the lee side. The minimum occurs in February, with another secondary minimum in midsummer, when the trades are weakest.

Over the Isthmus of Panama rains are fairly heavy.[4] Here we again find, considering the Canal Zone as a whole, two annual rainfall maxima, one in May and the second in October. The seasonal minimum occurs during the first three months, March usually being the driest month. The rains are, to a large extent, convective,[5] thunderstorms being frequent, especially over the Isth-

[1] The preparation of this paper was begun in connection with a course in "Climates of the World" conducted by Prof. C. F. Brooks, at Clark University Summer School 1921.

[2] In order to get the longest normals conveniently available, the following were referred to:
(a) Hann's *Handbuch der Klimatologie*, Stuttgart, 1908-1911, vols. 2 and 3.
(b) Voss: *Niederschlagsverhältnisse von Südamerika, Petermanns Mitteilungen*, Gotha, 1907.
It is recognized that the averages given are in some cases based on short records, but it is obvious that the essential characteristics of longer records, with respect to seasonal distribution of rainfall, would be the same.

[3] R. DeC. Ward, *Climate*, G. P. Putnam's Sons, 1908-1918, pp. 84-85.

[4] F. D. Willson, The climatology and hydrology of the Panama Canal, *Proceedings International Engineering Congress*, San Francisco, Calif., Sept. 20-25, 1915.

[5] H. G. Cornthwaite, Panama rainfall, MONTHLY WEATHER REVIEW, May, 1919, 47: 298-302.

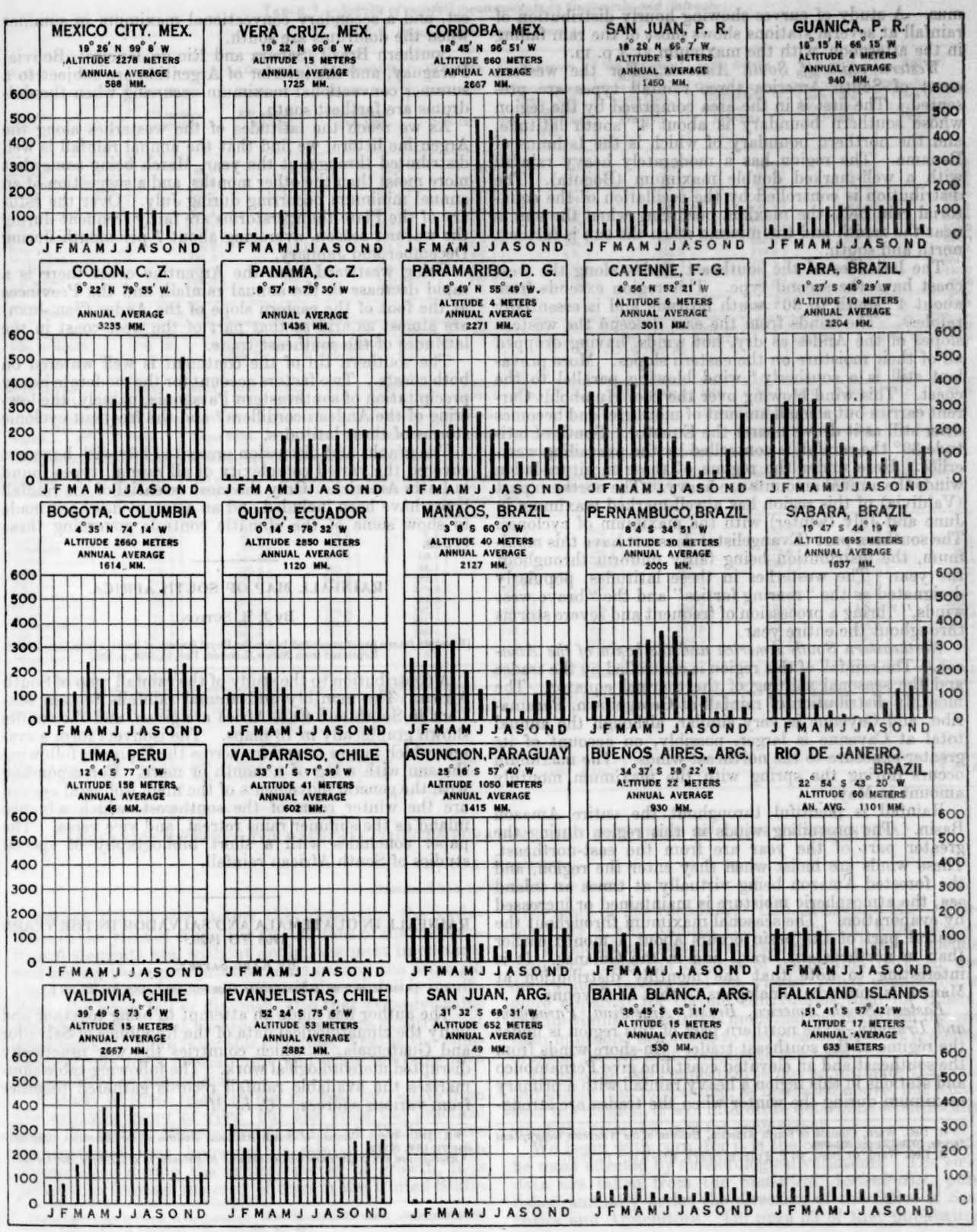

FIG. 1.—Latin American rainfall types.

mus. A study of curves showing hourly distribution of rainfall at several stations shows most of the rain falling in the afternoon, with the maximum at 3 p. m.

Western coast of South America.—For the western coast of South America three rainfall types are presented. The first is in the area comprised by the region whose southern boundary is about 4° south latitude, and the northern boundary of which is the Isthmus of Panama. The region has a moderately heavy rainfall with a well-marked double maximum (Bogota). The distribution is controlled by the oscillation of the equatorial rain belt, the maxima occurring when the sun is near the zenith and the minima when the sun is farthest north and south.

The latitudes of the southeast trades along the west coast have the second type. This region extends from about 4° south to 30° south latitude and is essentially rainless. The winds from the east descend the western slopes of the Andes as dry, hot winds, having dropped all of their moisture on the eastern slopes. More prevalent still is a southerly [6] wind blowing parallel to the coast. This wind blowing over the cool Humboldt Current carries but a small amount of moisture, and becomes drier still as it draws nearer the Equator. South of latitude 30° the rainfall is controlled by the prevailing westerlies. Here under the régime of these mositure-laden winds the annual amounts are heavy. The northern part (Valdivia) of this region has a well-marked maximum in June and July (winter) with the maximum of cyclones. The southern part (Evangelista) does not have this maximum, the distribution being fairly uniform throughout the year. The westerlies in these latitudes, popularly designated as the "roaring forties" and the "brave west winds," [7] bring a procession of frequent and severe storms throughout the entire year.

Northeastern South America and the basin of the Amazon.—The rainfall of this region is controlled by the trades and the seasonal shifting of the thermal equator. The monthly distribution of rainfall at Georgetown, Paramaribo, and Cayenne is very similar, although the annual total at Cayenne is larger, possibly, on account of its greater exposure to the northeast winds. The maximum occurs during the spring with the maximum monthly amount in May.

Rainfall is plentiful throughout the entire Amazon Basin. The prevailing winds in this region during the greater part of the year are from the east-northeast. These winds are moist when they enter the region, and the forested Amazon being virtually at times an inland sea, the atmospheric moisture is maintained or increased by evaporation. The seasonal maximum throughout the central part of the basin occurs about a month earlier than in northeastern Brazil and in the Guianas. It is interesting to note that the monthly distribution at Manaos is somewhat analogous to that at Cayenne.

Eastern South America, Brazil, Argentina, Paraguay, and Uruguay.—The northern part of this region is under the régime of the southeast trade. On-shore winds from the southeast and an elevated coast line give Pernambuco and stations in this region a heavy rainfall with a primary maximum during the winter when the trades are strongest, and a secondary convectional maximum in summer when the doldrums are south.

Southern Brazil (Sabara and Rio de Janeiro), Bolivia, Paraguay, and the interior of Argentina are subject to a summer convectional maximum occurring when the doldrums are farthest south.

As we reach the latitudes of the westerlies along the Argentine littoral we find that the annual rainfall is well distributed throughout the year, March being somewhat more moist than the other months, and a suggestion of an annual minimum occurring during July. Over the estuary of the Plate thunderstorms are fairly frequent during the warmer season, averaging about 7 per month during December and January.

Going westward from the Argentine coast there is a rapid decrease in the annual rainfall, and the Provinces at the foot of the eastern slope of the Andes (San Juan) are almost as arid as that part of the west coast in the latitudes of the southeast trade.

The southern tip of the continent is well watered on both coasts. Two factors account for the moderate heavy precipitation of southeastern Patagonia, namely, the lowering of the Andean cordillera,[8] and the frequent cyclonic storms of these latitudes.

The graphs and discussion presented herewith have not covered the varied complexity of all rainfall types found in Latin America. Only the most essential of the rainfall types have been included and an attempt has been made to show some of the climatic controls governing these types.

[6] R. DeC. Ward, Climate of South America, *Bulletin of the American Geographical Society*, 1903–357, pp. 353–360.

[7] R. DeC. Ward, *Climate*, G. P. Putnem's Sons, 1908-1918, pp. [illegible].

[8] R. DeC. Ward, Climate of South America, *Bulletin of the American Geographic Society*, 1903, 35:359.

RAINFALL MAP OF SOUTH AFRICA.

By J. R. SUTTON.

[Excerpts from a paper presented before the Royal Society of South Africa, Oct. 20, 1920. Reprinted from *Nature*, London, Dec. 16, 1920, p. 522.]

A contribution to the study of the rainfall map of South Africa. The monthly and annual rainfalls for 567 stations in South and East Africa are given, and the results shown graphically in 13 maps. The isohyets form a system which moves to and fro across the Equator, following the sun with a lag of a month or more. Corresponding with the general movements of the main isohyetal system are the winter rains of the southwest, which advance inland as the summer rains retreat, and vice versa. The paper concludes with a short bibliography of special studies of South African rainfall.

RAINFALL IN GUATEMALA AND SALVADOR IN THE YEARS 1908 TO 1920.[1]

By KARL SAPPER.

[Abstracted from *Meteorologische Zeitschrift*, Sept., 1921, pp. 279–281.]

The author has made an attempt to bring together and unify the climatological data of the Republics of Salvador and Guatemala, in which countries the war practically disrupted meteorological work. The following table summarizes the available rainfall records gathered together from various sources.—*C. L. M.*

[1] *Regenfall in den Republiken Guatemala und El Salvador in den Jahren 1908 bis 1920.*

TABLE 1.—*Results of rainfall measurements in Guatemala and Salvador.*

[Means for given periods in mm.]

Station	San Luis.	La Concepcion.	La Candelaria.	El Sororro.	El Reposo.	San Francisco, Miramar.	Santa Amalia.	El Rosario, Bela de Oro.	Bolivar.
Department	San Marcos.	San Marcos.	San Marcos.	San Marcos.	Quezaltenango, Costa Cuca.	Quezaltenango, Costa Cuca.	Quezaltenango, Costa Cuca.	Quezaltenango, Costa Cuca.	Quezaltenango, Costa Cuca.
Altitude	650 meters.	820 meters.	860 meters.	(?)	180 meters.	740 meters.	800 meters.	900 meters.	1,000 meters.
Period	1909–1919	1909–1919	1909–1919	1916–1919	May, 1913–Dec., 1919.	1908–1919	1909–1919	1911–1919	1909–1919
January	49.9	35.5	41.9	58.9	30.6	30.9	29.0	43.8	44.5
February	92.8	51.9	49.0	102.1	31.7	35.7	27.8	31.4	42.3
March	123.6	114.2	107.1	166.9	51.5	69.0	63.2	70.3	86.3
April	311.5	266.8	261.5	270.1	164.0	242.9	232.5	195.9	241.9
May	608.8	514.7	508.9	708.2	267.8	495.0	421.7	448.0	511.1
June	712.2	639.2	650.4	780.1	496.1	647.5	639.3	608.4	692.5
July	539.7	463.7	448.9	640.8	319.4	440.3	513.8	476.3	557.2
August	658.0	519.1	545.6	643.0	390.5	591.5	630.3	539.1	647.9
September	792.0	691.0	672.4	821.1	428.3	753.3	822.6	657.9	812.6
October	697.4	600.2	630.7	527.6	522.5	689.3	709.3	560.4	651.7
November	250.5	138.5	111.9	256.2	105.0	144.7	173.4	151.0	187.7
December	58.7	89.7	87.5	82.3	2.7	55.2	46.0	50.1	66.0
Year	4,895.1	4,124.5	4,115.8	5,057.5	2,741.6	4,194.4	4,308.9	3,832.8	4,540.8
Max. in month	Sept. 16: 1,031.6	Sept. 9: 1,113.4	Sept. 9: 1,126.2	Sept. 18: 969.6	Oct. 17: 1,013.0	Sept. 9: 1,244.6	Sept. 19: 1,055.9	Sept. 18: 1,018.6	Sept. 18: 1,235.3
Min. in month	Dec. 12: 0	Jan., Feb. 10: 0 Feb. 12: 0	Jan., Feb. 10: 0 Feb. 12: 0	Jan. 19: 1.3	Dec. 13,14,16–19: 0 Feb. 15, Mar. 16, Feb. 18: 0	Jan. 10, Feb. 19, Mar. 9, Dec. 10: 0	Jan. 12: 0	Dec. 18: 4.9	Dec. 18: 0
Max. in year	1909: 5,946.1	1909: 5,352.5	1916: 5,554.0	1916: 5,355.0	1917: 3,487.4	1909: 6,065.0	1916: 5,880.7	1916: 5,179.3	1916: 6,745.0
Min. in year	1912: 3,966.4	1914: 3,025.1	1912: 3,204.8	1919: 4,834.0	1919: 2,704.4	1913: 2,850.6	1914: 2,760.2	1914: 2,689.0	1912: 3,405.9

Station	El Pensamiento.	Santa Sofia.	Morelia.	Magdalena.	Setal.	Chinasayub.	Chimax.	Samac.	Seritquiché.	San Salvador.
Department	Quezaltenango. (Chuvá.)	Chimaltenango.	Chimaltenango.	El Quiché.	Alta Verapaz.	Alta Verapaz.	Alta Verapaz.	Alta Verapaz.	Alta Verapaz.	Republic of Salvador.
Altitude	1,200 meters.	760 meters.	980 meters.	2,200 meters.	730 meters.	950 meters.	1,306 meters.	1,300 meters.	.....	657 meters.
Period	1909–1919	1912–1919	1909–1919	1913–1919	1914–1920 except 1918.	1914–1920	1912–1920	1920	1920	1912–1920
January	36.4	47.0	51.0	6.5	314.9	313.7	146.2	189.0	201.0	13.7
February	44.2	58.0	74.0	3.0	334.7	256.4	101.6	245.2	119.0	13.5
March	102.2	100.0	105.4	30.9	283.3	222.1	131.7	172.0	64.0	24.7
April	213.1	256.4	190.7	34.1	286.7	288.3	143.7	132.1	77.0	72.8
May	411.8	641.3	581.9	80.7	311.9	335.3	199.2	354.0	474.0	167.8
June	668.4	816.4	763.8	170.6	462.6	519.0	285.5	651.3	818.0	298.0
July	488.5	693.5	559.4	139.5	405.9	512.3	250.4	228.5	690.0	306.8
August	547.8	680.9	708.3	137.7	402.7	396.4	234.7	195.0	417.0	298.9
September	621.7	941.4	901.7	181.3	576.1	588.5	263.7	743.4	781.5	260.0
October[1]	531.3	785.4	788.4	109.6	728.5	812.5	317.5	651.2	405.5	281.5
November[1]	144.7	186.4	183.3	29.2	773.6	653.4	308.2	941.2	396.0	42.3
December[1]	61.0	46.6	46.4	5.9	498.0	514.4	184.5	400.8	69.0	20.3
Year[1]	3,862.4	5,253.3	4,954.3	979.0	5,378.9	5,412.3	2,566.9	4,903.7	4,512.0	1,800.3
Max. in month	June 10: 1,138.5	July 16: 1,182.2	Oct. 9: 1,220.8	June 17: 286.5	Nov. 14: 1,182.5	Oct. 17: 1,257.0	Oct. 17: 545.0	Nov. 20: 941.2	Mar. 20: 64	.....
Min. in month	Feb. 15: 3.0	Dec. 19: 0	Jan. 10, Dec. 11, Feb. 14: 0	5 times Jan., 4 times Feb. & Mar. 1 time May 3 times Dec.: 0	May 15: 129.0	Mar. 17: 85.0	Feb. 13: 26.0	Apr. 20: 132.1	June 20: 818	.....
Max. in year	1916: 4,512.0	1916: 6,084.5	1919: 5,545.3	1916: 1,312.1	1920: 6,603.5	1920: 6,452.0	1920: 2,996.2	.....	.....	1918: 2,119.0
Min. in year	1912: 3,002.0	1914: 3,588.5	1914: 3,704.5	1914: 458.0	1916: 4,199.5	1919: 4,645.0	1919: 1,877.0	.....	.....	1912: 1,478.5

[1] 10-year mean: Break in record, Oct. to Dec., 1918.

RELATION BETWEEN THE RAINFALL, THE TEMPERATURE, AND THE YIELD OF CORN IN ARGENTINA.[1]

By N. A. HESSLING.

[Translated from the Spanish by G. B. Diehl.]

Among the diverse factors that determine the variations in the yield of crops, the fluctuations of the meteorological elements are, without doubt, the most important, and among these precipitation must occupy the principal place. We know, naturally, that if the rainfall is insufficient, the crops fail or diminish; also that excessive rains are prejudicial. But we need to know more exactly what conditions are more favorable for crops, what is the minimum of rain for a normal crop, and when the rains turn to excessive or prejudicial.

A study of these relations has interest, not alone from the scientific point of view, but also from the practical side. In fact, J. Warren Smith and H. A. Wallace have demonstrated that, knowing the rainfall and the mean temperature during the critical period of growth, it is possible to forecast the crop of corn in the United States with more or less certainty. (MO. WEATHER REV., February, 1914, and August, 1920.) This, like other practical applications that these studies can have, depends naturally upon the degrees of connection between the determining factors and the yields. That connection is more apparent for certain cultivations than for others, and for similar cereals it is more marked in certain regions than in others, according to the greater or lesser presence of other factors that complicate the result.

In general, the connection is not so intimate that one can utilize it in forecasting, as indicated above, but whatever the method, it is of interest to determine scientifically what the relations are for each cereal.

We begin with corn, for it is the cereal that appears to be most affected by meteorological variations. The yield data are taken from the *Statistical Agriculturist*, published annually under the direction of the Office of Statistics and Agriculture. On page 53 of that publication

[1] Relaciones entre la lluvia, la temperatura y el rendimiento del maiz. *Boletin Mensual*, Oficina Meteorologica Nacional, Oct., 1918, pp. 487–492.

are given the areas sown and the yield in tons of the different cereals, since 1898 for corn, flax, and oats, and since 1890 for wheat. These data refer to the country as a whole, and with regard to corn they are the only ones that we have. It is not possible, therefore, to study the relations with this cereal for each Province or region.

In order to correlate these yields with the precipitation and temperature, it is necessary to have data that represent the conditions in conjunction with the corn-growing zone, formed by averages from a number of well-located stations. In order to attain this object, a map was made (map not reproduced); it was prepared with the data given in the publication before cited, respecting the area sown with corn in each Province. The rainfall data utilized in this study represent the average of 24 rainfall stations of which a proportionate majority are found within the area where the cultivation of corn is carried on more intensively. The full meteorological stations are not so numerous as the rainfall stations; neither is this necessary, because the temperature is an element much less variable than the rainfall; the average of six stations was employed.

TABLE 1.

Year.	Yield (in tons per 100 acres).	Rainfall (in millimeters).						
		October.	November.	December.	January.	February.	March.	October to January.
1898–9	2,000	74	113	143	109	78	180	439
1899–1900	1,400	58	82	89	68	112	220	297
1900–1901	2,000	72	110	49	81	52	86	312
1901–2	1,518	78	108	67	68	95	86	321
1902–3	2,100	73	86	103	69	98	142	331
1903–4	2,119	49	74	79	83	106	110	285
1904–5	1,563	93	122	51	68	69	93	334
1905–6	1,822	195	36	117	71	30	42	419
1906–7	639	49	75	67	39	55	185	230
1907–8	1,271	72	56	95	33	43	99	256
1908–9	1,513	74	128	78	62	75	22	342
1909–10	1,481	76	85	79	75	69	121	315
1910–11	219	30	45	26	49	101	21	170
1911–12	2,196	152	122	208	116	75	88	598
1912–13	1,304	98	139	111	17	75	146	365
1913–14	1,610	80	120	59	80	61	66	339
1914–15	1,965	107	155	141	112	152	77	515
1915–16	1,019	96	95	86	70	55	56	347
1916–17	412	21	52	95	57	108	73	225
1917–18	1,229	45	22	64	167	64	61	298
1918–19	1,706	75	105	85	107	92	148	372
1919–20	1,984	71	95	171	110	82	139	447
Average	1,503	80	92	94	78	79	103	344

Year.	Yield (in tons per 100 acres).	Temperature (° C.).						
		October.	November.	December.	January.	February.	March.	October to January.
1899–9	2,000	15.5	18.8	23.7	24.0	23.2	22.3	20.5
1899–1900	1,400	16.5	20.2	24.2	26.1	25.8	21.7	21.7
1900–1901	2,000	17.4	21.5	23.5	23.6	24.0	22.5	21.5
1901–2	1,518	20.2	21.0	23.7	26.3	26.4	23.0	22.8
1902–3	2,100	18.6	21.8	24.0	24.5	21.2	23.5	22.2
1903–4	2,119	17.4	21.6	23.8	24.3	22.2	21.1	21.8
1904–5	1,563	18.0	20.6	22.4	24.1	22.8	22.6	21.3
1905–6	1,822	17.5	20.9	23.3	25.3	25.5	24.3	21.8
1906–7	639	19.4	21.7	23.3	26.4	25.5	21.6	22.7
1907–8	1,271	17.1	21.0	24.2	25.2	24.5	22.9	21.9
1908–9	1,513	18.2	21.2	24.2	26.2	24.0	22.0	22.4
1909–10	1,481	16.9	18.9	23.0	25.4	23.4	19.7	21.0
1910–11	219	17.8	22.0	25.5	26.3	23.6	20.4	22.9
1911–12	2,196	16.8	21.0	22.6	25.4	24.3	22.6	21.4
1912–13	1,304	18.6	20.7	24.9	26.1	26.8	21.3	22.6
1913–14	1,610	17.5	21.5	23.5	26.6	24.6	21.0	22.3
1914–15	1,965	17.3	19.2	21.9	24.2	24.3	20.2	20.6
1915–16	1,019	18.5	22.3	24.6	26.0	25.2	21.8	22.8
1916–17	412	20.3	23.5	24.4	27.9	25.2	21.8	24.0
1917–18	1,229	17.8	22.6	26.6	26.0	24.7	22.4	23.2
1918–19	1,706	17.9	21.9	25.0	27.2	24.3	22.3	23.0
1919–20	1,984	17.7	20.6	24.4	26.4	24.2	22.8	22.3
Average	1,503	17.9	21.1	23.9	25.6	24.5	22.0	22.1

Those who have made similar studies in England—Hooker, and in the United States—J. Warren Smith, Blair, and others, have generally determined the degree of connection between the determining factors and the yields by means of the correlation coefficient. This formula presupposes the correlation between the different factors to be a straight line, the variations of the one factor always being proportionate to the other, that is to say, or would be in this particular case, that the yield always would increase with the same amount of precipitation. Logically, this is not the case, but one must have a point at which the increase in yield is stopped, and where it will presently diminish if the precipitation increases much more. We see, for example, when studying the relations in connection with wheat, that this cereal in our country suffers with more or less frequency from excessive as well as from lack of moisture. As the growth of corn takes place more or less in summer, when evaporation is more active, and the necessity for moisture is consequently greater, and, moreover, the plant for physiological reasons needs more water, this cereal does not suffer generally from excessive precipitation, although the relation is not a straight line; nevertheless it approximates to that condition, and as the correlation coefficient is a convenient method for expressing different degrees of connection, it can be utilized in order to see in what months the correlation is more marked. These coefficients are given in Table 2.

TABLE 2.—*Correlation coefficients of the yield of corn with the precipitation and temperature of different months.*

	Precipitation.	Temperature.
October	0.46	−0.49
November	0.45	−0.47
December	0.52	−0.35
January	0.46	−0.61
February	0.04	−0.28
October to January	0.71	−0.64

The coefficients can vary between 1.0 and −1.0, expressing these two extreme correlation values perfectly in a direct sense and in an inverse sense, respectively. Zero or values near zero indicate that there is no correlation, or that, if there is, it is not a straight line.

The values obtained in this case indicate that the yield of corn depends, to a great extent, on the rainfall during the months October to January, and in a negative sense on the mean temperature in the same months. Nevertheless, in February the temperature influenced somewhat, but the precipitation had no influence. In the individual months the influence is nearly equal with respect to precipitation for each of the four months, while temperature shows its greatest influence in January. This diminution of the coefficient for December is not well explained, which must probably be attributed to accidental causes. The correlation is greater for the two elements when we consider the four months in conjunction than for any individual month, which explains itself, because, if the conditions are unfavorable one month this can be compensated for in part in other months. The difference between the correlation of the individual months and that of the four months will no doubt be great, if not out of place, for the reason that the meteorological elements have certain passive or permanent principles, that if one month is rainy, or dry, cold or hot, it is probable that the following month will be of the same character, a principle which generally does not affect the compensation from one month to the other. In order to know this degree of permanence between the months in question, the correlation coefficient between one month and another has been

calculated with respect to the precipitation and to the temperature, the following result being obtained:

Precipitation:

October-November, 0.22; October-December, 0.48; October-January, 0.07. November-December, 0.29; November-January, 0.03; December-January, 0.33.

Temperature:

October-November, 0.63; October-December, 0.18; October-January, 0.53. November-December, 0.56; November-January, 0.51; December-January, 0.50.

As is seen, there is always more probability that the general character of a month will be like the months

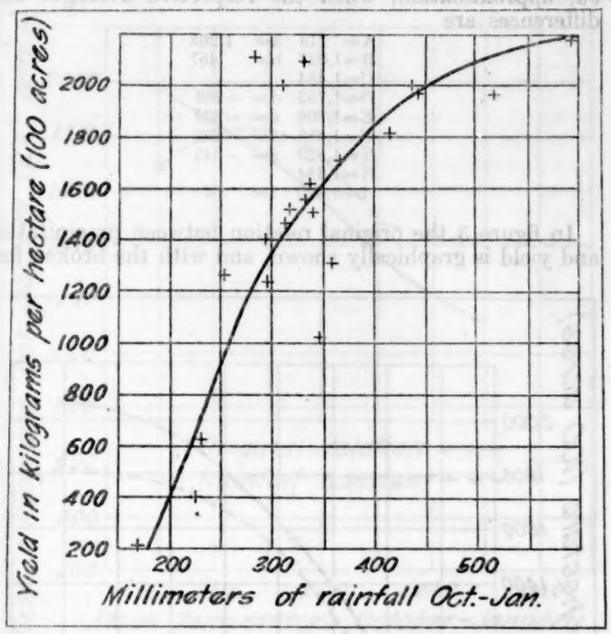

FIG. 1.—Relation between the rainfall and the yield of corn.

preceding, and also that the various months will preserve this character, which proves that the causes that determine this character are not transitory phenomena, but that they must be phenomena that alter slowly. Of the two elements, the temperature is the more stable with respect to time, as well as geographically.

The correlation coefficients of Table 2, as has already been said, give a relative measurement, but as an absolute measurement of the correlation will be incorrect, it must be that the relation is not a straight line. In the diagrams, figures 1 and 2, the natural verity of the correlation can be seen. The year of greatest yield corresponds to the year of greatest rainfall, and the minimum yield to the least rainfall, but it is easy to see that the increase in yield with the rainfall is not constant, being greater for the first 300 millimeters, diminishing gradually thereafter, as shown by the points of intersection between precipitation and yield grouped around the curved line, such as is traced on the figure. Except five or six, the points generally remain close to this line. In taking the relation with the temperature, we can very well express it by means of a straight line, but in this case there is more dispersion of the points indicating a lesser degree of correlation.

The influence of temperature, as has been seen, is negative, that is to say, when the temperature is low it is much more favorable for corn. The question occurs, is this fact true, or only apparent because the temperatures are much lower precisely in the periods of most rainfall, and higher in times of dryness. In fact, the correlation coefficient between these two elements is -0.52 (this is for the months of October to January, therefore in the winter it does not happen the same), which indicates that none of the factors are completely independent. Therefore, it is necessary to ascertain the effect of each one of these independent of the other, or what would be the effect of the rainfall, supposing the temperature constant, and the effect of the temperature with the precipitation constant. If the correlations were rectilinear, this could be done by the method of partial correlation. As the relation with the precipitation does not satisfy this condition, I utilized for this object a new method, invented by George F. MacEwen and Ellis L. Michael, described in the *Proceedings of the American Academy of Arts and Sciences*, December, 1919, vol. 55, No. II. Applying it to the present case, the method consists in obtaining a series of averages of yield, corresponding to a series of averages of precipitation, corrected to a temperature constant, and a similar series of averages of yield, corresponding to average temperatures corrected to a precipitation constant. These corrections are found by a method of successive approximations. The computations are too long to give in detail, but as a new method is employed, it will be well to give the proceedings succintly.

The first step consists in arranging the precipitation and temperature data in the order of ascending magnitude with the corresponding yield data; then making up

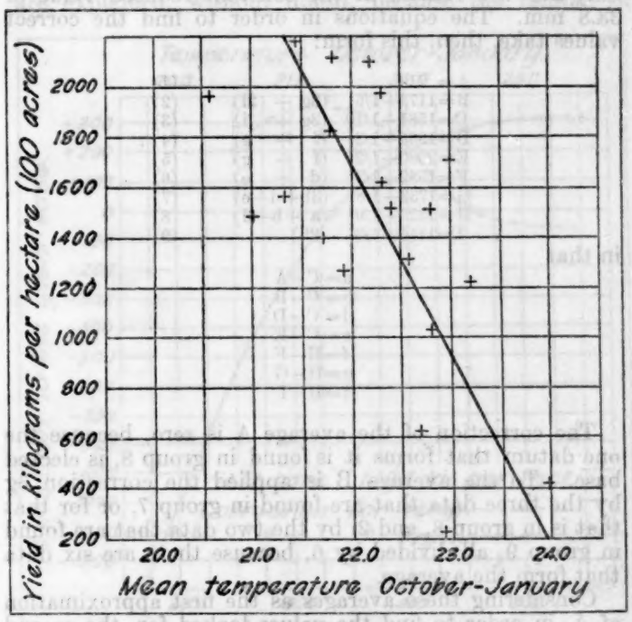

FIG. 2.—Relation between the temperature and the yield of corn.

two series of averages of a number of suitable yield groups corresponding to the precipitation and temperature. Each individual yield fact will then be represented in some group of each series, and according as they occur in respective groups, the corrections are applied in order to reduce them to a precipitation and temperature constant. The number of groups employed in this case is five for rain and four for temperature. These numbers have been adopted with the idea that each group should remain within definite limits; for example, join in one group the precipitation of 200 to 300 millimeters, in

another 300 to 400, etc. It would be advantageous also to have each group contain the same approximate number of data, but it is not possible to satisfy these two conditions, for when values near the normal are more frequent than those which deviate greatly, this last condition has been sacrificed in favor of the first.

In Table 3 are given the averages corresponding to each group, the number that form the data N of each group, and the number of times that the individual n data of the group are found in each group of the opposite series.

TABLE 3.

Group.	N	Average rainfall (millimeters).	Average yield (in tons per 100 acres).	n6	n7	n8	n9	Group.	N	Average temperature (centigrade).	Average yield (in tons per 100 acres).	n1	n2	n3	n4	n5
1	1	170	A_1 219	.....	.....	1	.....	6	2	20.5	F_1 1,982	.....	.....	.....	1	1
2	6	265	B_1 1,178	.....	3	1	2	7	8	21.5	G_1 1,732	.....	3	3	1	1
3	10	338	C_1 1,581	.....	3	6	1	8	9	22.6	H_1 1,323	1	1	6	1	...
4	9	435	D_1 1,935	1	1	1	.....	9	3	23.4	I_1 1,116	.....	2	1	.....	...
5	2	556	E_1 2,080	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...

We take as base yields the averages of groups 3 and 8, that is to say, to correct the rainfall by the effect of the temperature, supposing it to be constant in this value, or to be 22.6°, and correct the temperature by the rainfall; this will remain at the constant reduced value of 33.8 mm. The equations in order to find the correct values take, then, this form:

$$A = 219 \quad (1)$$
$$B = 1178 + 1/6\,(3g + 2i) \quad (2)$$
$$C = 1581 + 1/10\,(3g + i) \quad (3)$$
$$D = 1935 + 1/3\,(f + g) \quad (4)$$
$$E = 2080 + 1/2\,(f + g) \quad (5)$$
$$F = 1982 + 1/2\,(d + e) \quad (6)$$
$$G = 1732 + 1/8\,(3b + d + e) \quad (7)$$
$$H = 1323 + 1/9\,(a + b + d) \quad (8)$$
$$I = 1115 + 1/3\,(2b) \quad (9)$$

in that

$$a = C - A$$
$$b = C - B$$
$$d = C - D$$
$$e = C - E$$
$$f = H - F$$
$$g = H - G$$
$$i = H - I$$

The correction of the average A is zero, because the one datum that forms it is found in group 8, is elected base. To the average B is applied the correction 3g by the three data that are found in group 7, or for that that is in group 8, and 2i by the two data that are found in group 9, all divided by 6, because there are six data that form the average.

Considering these averages as the first approximation of A, in order to find the values looked for, the second approximation of A, B, C, D, and E is obtained by substituting in the equations (1) to (5) the first approximations to f, g, and i, that is:

$$f_1 = H_1 - F_1 = -659$$
$$g_1 = H_1 - G_1 = -409$$
$$i_1 = H_1 - I_1 = 208$$

Summing up said equations we would have:

$$A_2 = 219.0 \quad a_2 = 1260.1$$
$$B_2 = 1{,}042.8 \quad b_2 = 436.3$$
$$C_2 = 1{,}479.1$$
$$D_2 = 1{,}579.0 \quad d_2 = -99.9$$
$$E_2 = 1{,}546.0 \quad e_2 = -66.9$$

Now substituting the values a_2, b_2, d_2, and e_2, in the equations (6) to (9), we obtain the second approximation F_2, G_2, H_2, and I_2; and f_2, g_2, and i_2, that were substituted in the equations (1) to (5), will give the third approximation of A, B, etc.

If we continue these successive approximations, the values converge, that is to say, the difference between one approximation and the following will be diminishing until zero, when the two base averages will also be equal. This result has been obtained in the present case in the 9a, approximation, when the respective averages and differences are

$$A = 219 \quad a = 1{,}265$$
$$B = 1{,}027 \quad b = 457$$
$$C = 1{,}484$$
$$D = 1{,}753 \quad d = -269$$
$$E = 1{,}806 \quad e = -322$$
$$F = 1{,}686 \quad f = -202$$
$$G = 1{,}829 \quad g = -345$$
$$H = 1{,}484$$
$$I = 1{,}420 \quad i = 64$$

In figure 3 the original relation between precipitation and yield is graphically shown, and with the broken line

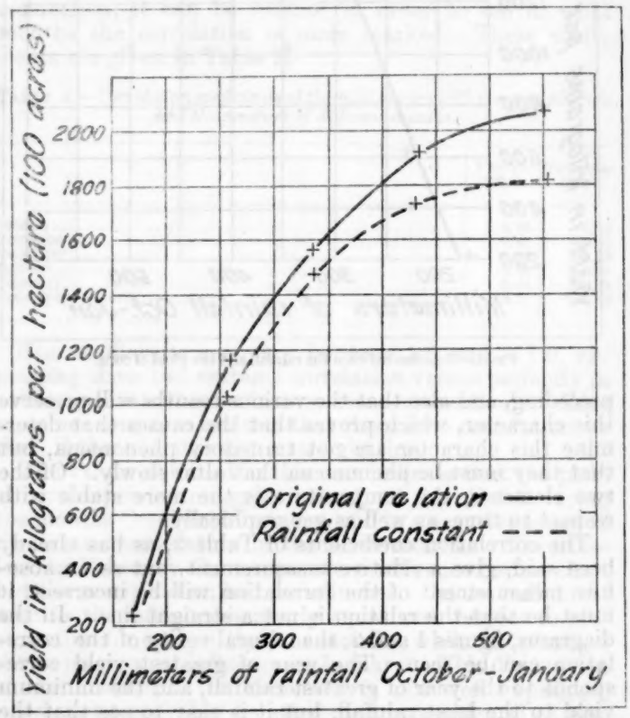

FIG. 3.—Relation between the rainfall and the yield reduced to five averages.

the same relation supposing the temperature to be constant. As is seen, this last line has a curve more pronounced, that is to say, the effect of the rainfall diminishes more rapidly. The explanation of this is, evidently, that favorable rainfall conditions are generally accompanied by favorable temperature conditions, and if this should be constant, the effect of the precipitation only, naturally would be less.

In the diagram, figure 4, it is seen by the lesser amplitude of the curve that the effect of temperature over yield is much less than the effect of rainfall, and when the effect of the rainfall is simultaneously subtracted this amplitude is reduced still more. Moreover, in its original form, this correlation is a straight line diminishing the

yield with the rising of the temperature, but correcting by the effect of the rainfall, it is seen that too low temperatures are also prejudicial. Logically, it could be expected that it would be so, and if we could have yield data for Provinces, probably we should see that, in the south of the corn zone, this dimunition by too low temperatures follows with more frequency than in the north. The most favorable temperature is around 21.0 to 21.5° C., for the months of October to January, higher tem-

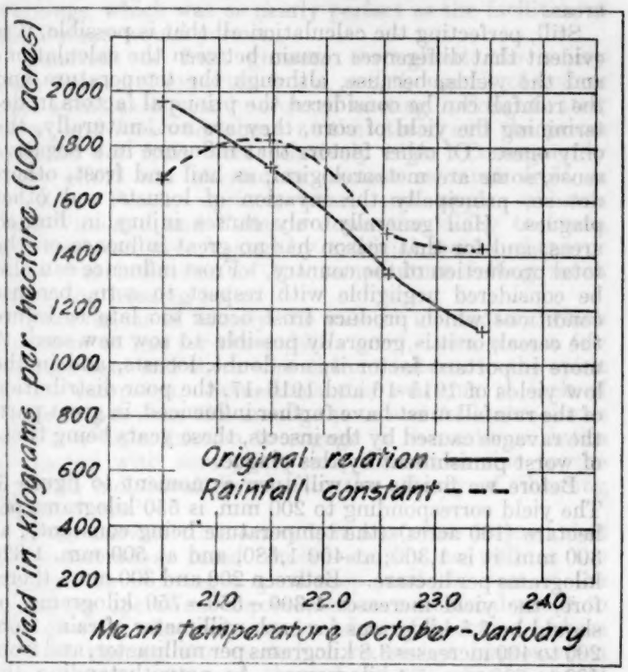

FIG. 4.—Relation between the temperature and the yield of corn reduced to four averages.

perature being prejudicial. This inverse effect of temperature probably must be attributed to the increase of evaporation with temperature, although the curve is not parabolic, as would be expected if this supposition was correct, in virtue of the more rapid increase of evaporation than temperature. Nevertheless, as very little part of these data are disposable, much depends on the method of forming the groups. In the year of least yield; that is to say, the temperature was 22.9° C., higher than included in group 8. If this year had been included in the last group, the result would have been different. There are also certain limitations to solving these questions by purely statistical methods, which should be examined closely; and the most that we can hope for is to arrive at some approximation.

With the differences a, b, d, etc., we can determine the correction applicable to the base yield (1,484 kilograms), in order to calculate the yield, knowing the rainfall and temperature. As in all cases, the result will only be approximate, it will be sufficiently correct to do the interpolations between said values graphically, as has been done in figure 5.

Calculating by means of this graph, the yield for the year 1898–99, for example, we have: Rainfall from October to January, 439 mm.; correction given by the perpendicular line (ordinate) corresponding to this quantity of rainfall, +270; temperature, 20.5°; correction, +202; that is to say, 1,484+270+202=1,956. In Table 4 are given the yields calculated by this method for all the years from 1898 to 1919, and the difference that resulted subtracting this calculated yield from the actual yield.

TABLE 4.—*Yield of corn calculated for the rainfall and the temperature October to January.*

Year.	Calculated yield (tons per 100 acres).	Difference between calculated and actual yields.	Year.	Calculated yield (tons per 100 acres).	Difference between calculated and actual yields.
1898–99	1,956	44	1909–10	1,714	−233
1899–1900	1,579	−179	1910–11	174	45
1900–1901	1,699	301	1911–12	2,154	42
1901–2	1,379	139	1912–13	1,559	−255
1902–3	1,584	516	1913–14	1,584	36
1903–4	1,484	635	1914–15	2,014	− 49
1904–5	1,794	−231	1915–16	1,479	−160
1905–6	2,014	−192	1916–17	644	−232
1906–7	734	− 95	1917–18	1,209	20
1907–8	1,209	62	1918–19	1,539	167
1908–9	1,519	− 6	1919–20	1,854	130

In three cases the differences amounted to 30 per cent of the normal, but in the rest of the years the differences are not more than 20 per cent, although the differences are considered, and are considerable, compared with the usual variations from year to year, they are really small as is seen by the graph, fig. 6.

The low yields of crops obtained in 1904–5 and 1912-13 are explained, without doubt, because the rainfall of

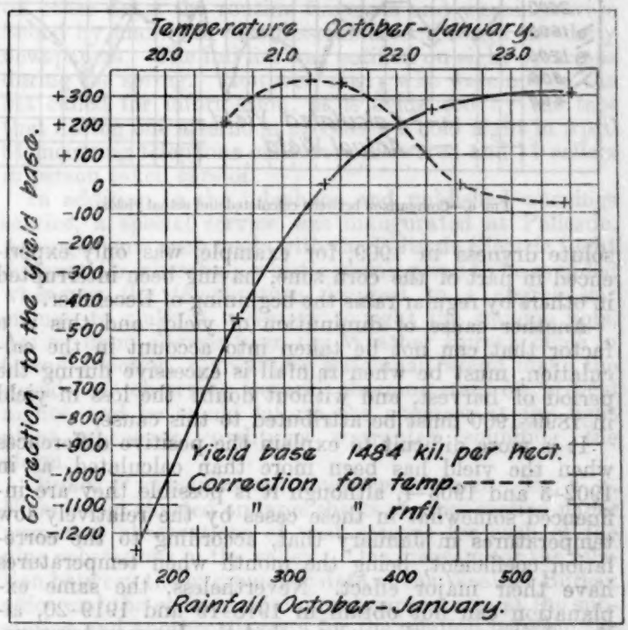

FIG. 5.—Corrections corresponding to different temperatures and rainfall for calculating the yield of corn.

December in the first place, and of January in the second, was very much below the normal, although the total rainfall for the four months was more or less normal. In consequence of this, the differences will probably be reduced somewhat if the effect of each month is considered separately. Nevertheless, some large differences remain, and in order to make the calculations more dependable, and to strengthen them, it would be necessary to so consider the rainfall, likewise temperature

under other aspects, principally the distribution of the rainfall, or, this being so, to make the periods less than a month. The low yield of 1915–16, for example, is explained, because, although the total rainfall of each month was more or less normal, it occured in small, vigorous showers, with long intervals of dryness. The rainfall of January practically all fell on the 15–16th, not having rained before since the middle of December. This appeared to be exceeded in 1909–10, when there was an absolutely dry spell to the north of Buenos Aires from November 25 until December 18, only interrupted in localities by small falls that, in reality, only intensified the dryness, because instead of penetrating to the roots they formed a crust on the surface that facilitated evaporation.

It is natural that these long periods of dryness caused injury to the plants, which can be compensated for only partially by later rains. It would evidently be of interest to find out which is the critical period of growth of the plants, that is to say, in which period was the lack of rainfall more harmful; but, in order to do this, it would be necessary to have yield data over all of the Provinces, and also over all of the periods of seedtime and harvest, although these vary according to the Provinces, and also from one year to the other. The period of absolute dryness in 1909, for example, was only experienced in part of the corn zone, having been interrupted in others by regular rains the beginning of December.

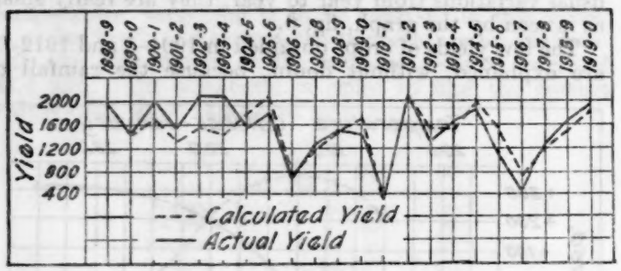

FIG. 6.—Comparison between calculated and actual yields.

Another cause of diminution of yield, and this is a factor that can not be taken into account in the calculation, must be when rainfall is excessive during the period of harvest, and without doubt the loss in yield in 1899–1900 must be attributed to this cause.

It is more difficult to explain the positive differences when the yield has been more than calculated, as in 1902–3 and 1903–4, although it is possible they are influenced somewhat in these cases by the relatively low temperatures in January that, according to the correlation coefficient, being the month when temperatures have their major effect. Nevertheless, the same explanation can not obtain in 1918–19 and 1919–20, although it was in these years that the January temperature was very high. For the rest, the distribution of the rainfall, although in some years it can be unfavorable, in others has been favorable and worked toward the making of a yield superior to the mean conditions.

In résumé, the factor most important in the yield of corn in our country is the rainfall from October to January, inclusive, and in the second place, the temperature during the same time. With these two factors it is possible to calculate the yield with sufficient accuracy, and therefore, knowing the area sown, the amount of the total crop of the country at the end of the month of January, which is of evident interest, as the harvest in general does not begin until March.

The calculation, as has been seen, would probably perfect itself considering these elements by periods; for example, for weeks or decades, although much complication of the question would result and, moreover, in order to estimate each one of these elements correctly for the lesser periods, it would be necessary, as has already been said, to arrange the yield data by Provinces or lesser areas.

Still, perfecting the calculation all that is possible, it is evident that differences remain between the calculations and the yields, because, although the temperature and the rainfall can be considered the principal factors in determining the yield of corn, they are not, naturally, the only ones. Of other factors that influence in a negative sense, some are meteorological, as hail and frost, others not so, principally the invasion of locusts and other plagues. Hail generally only causes injury in limited areas, and for that reason has no great influence on the total production of the country. Frost influence can also be considered negligible with respect to corn, because conditions which produce frost occur too late to injure the cereal, or it is generally possible to sow new seed. A more important factor is, no doubt, locusts, and in the low yields of 1915–16 and 1916–17, the poor distribution of the rainfall must have further influenced, in great part, the ravages caused by the insects, these years being those of worst punishment by this plague.

Before we finish, we will turn a moment to figure 5. The yield corresponding to 200 mm. is 550 kilograms per hectare (100 acres) (the temperature being constant); at 300 mm. it is 1,300; at 400 1,680, and at 500 mm. 1,820 kilograms per hectare. Between 200 and 300 mm., therefore, the yield increases $1,300-550=750$ kilograms, or should be 7.5 kilograms for each millimeter of rain; from 200 to 400 increases 3.8 kilograms per millimeter, and from 400 to 500 mm. 1.4 kilograms. As, notwithstanding, the rainfall generally comes accompanied by favorable temperature conditions, according to an approximate calculation, and in order to have a computation of the two elements, we can take the expressed yields by the continuous line. This we do for rainfall until 300 mm., 8 kilograms, more or less, per 100 acres for each millimeter; for 300 to 400 mm. four kilograms for each millimeter, and above 400 mm. 2.4 kilograms per millimeter.

In the last year of those that enter into this study, 1919–20, the area sown was 3,312,200 hectares. A millimeter of rainfall, until 300 mm. for the four months is reached, would equal, then, 26,500 tons, or at the price $10 a hundredweight, two millions and a half of dollars, more or less. In proportion as the rainfall increases, its value will be diminishing, but as respects corn its value will always increase, except during harvest, or at least in the 22 years that are used in this study there is no evidence that corn has suffered from excessive rainfall during growth. The calculated values, as are drawn by a mean curve, refer to mean conditions of distribution, and if the distribution of rainfall should be poor its value will be less, as also it will be greater if the distribution is especially good.

If the rainfall observers would say to themselves that each millimeter of rainfall can be worth millions of dollars to the country, perhaps they would have more interest in the observations, which are not always made with the care that could be wished for.

FRUIT-FROST WORK IN THE GRAND VALLEY OF COLORADO.

By ANDREW M. HAMRICK, Meteorologist.

[Weather Bureau, Davenport, Iowa, Sept. 10, 1921.]

About 10 years ago the Grand Valley of Colorado was the center of one of the most active orchard-heating campaigns then being conducted in the fruit belts of the United States. Mr. E. S. Nichols, the meteorologist at Grand Junction, spared neither time nor labor in developing a system of forecasting, and dissemination of warnings, which was as nearly perfect as the facilities of the Bureau would permit.

Hundreds of fruit growers throughout the valley were warned of expected frosts, and thousands of dollars were spent each year in orchard heating. Freight rates, labor, and fuel were cheap at that time, and the prices received for fruit were relatively high. Consequently every effort was exerted to protect as much fruit as possible. Peach, apricot, pear, and apple orchards from Vineland and Palisade down the valley to Loma and Garmesa were heated by artificial means whenever there was indication of the temperature falling much below the freezing point.

However, as is usually the case in all matters which are more or less for the public's good, there were a few growers here and there who did not enter into the spirit of the campaign. Sometimes this was due to lack of funds to purchase the smudge pots and fuel; sometimes due to a disinclination to engage in the arduous duties connected with smudging; and, sometimes due to the grower's individual disbelief in the efficacy of "heating all-out-doors."

When harvest time arrived, it was often learned that the nonsmudger fared almost equally as well as the smudger in securing a good crop, and the cost of the smudging operations represented an additional profit to the grower who did not smudge. Of course, where orchard heating was carried on on such a large scale a few growers scattered throughout the district could refuse to smudge and yet their orchards would reap the benefits of the combined efforts of their neighbors, principally, because the difference in temperature between a heated and a nonheated orchard would soon set up a circulation of air beneficial alike to all concerned.

There was an inclination on the part of the nonsmudgers to boast of their success (another common trait of this class of slackers) in saving the labor and expense of smudging, and year after year new converts were added to the side that did not smudge.

Then came the World War, with its resultant high freight rates, high labor wages, and high cost of fuel, while the price of fruit (as it affected the producers), did not increase proportionately. Especially was this true of the more common fruits—apples and pears. As a result, all apple growers in the lower valley stacked up their smudge pots, and abandoned the practice of orchard heating. In the upper part of the valley, around Vineland and Palisade, the early apricots, peaches, and some early pears sold for so much more than apples per box that the growers were able to meet the increased cost of production and marketing, and still continue their protective measures.

As a result of this change in economic conditions, orchard heating had dwindled from a general community proposition in 1911 to a purely local problem in 1921. In the spring of the latter year it was confined to the Palisade peach and apricot district, with perhaps a half dozen growers outside of that area who tried to protect a few trees in their gardens. And, even in the Palisade district, heating was not general. Nearly three-fourths of the growers within that area did not prepare to smudge, thus leaving the heated orchards so badly scattered as to diminish greatly the effectiveness of the practice.

Nevertheless, the Weather Bureau did not curtail its service to the growers who desired frost warnings; even, in fact improved it by the development of formulæ for predicting the minimum temperatures which might be expected each morning.[1] This latter work had been prosecuted during the war by Mr. E. S. Nichols, who had carried out and elaborated upon suggestions made by Prof. J. Warren Smith concerning the relation between hygrometric data and minimum temperatures, until he had perfected a system which was simple of operation and yet highly accurate if the state of weather for the following morning were definitely foretold.

Early in the spring of 1921, the Grand Junction Weather Bureau office sent out notices to the effect that the Bureau would be glad to furnish warnings and predictions of expected minimum temperatures to all who cared to receive them. As a result 22 fruit growers who intended to smudge asked to be listed for telephonic advices, and 18 growers who do not smudge requested the service. The people on the list were to be advised only on dates when dangerous temperatures were expected to occur; on other dates the routine forecasts and warnings were issued by mail, and also disseminated through the daily newspapers. The full list was notified on eight occasions during the spring. However, many who were not on the list called for information, as is evidenced by the fact that during one afternoon preceding a cold night in April 81 incoming telephone calls were answered and 11 callers in person taken care of.

In addition to the telephone and published warnings service, a special service was inaugurated at Palisade. Arrangements were made with the Palisade Electric Light & Power Co. whereby a whistle warning was to be sounded whenever the temperature dropped to a degree low enough to make it necessary to light the smudge pots. Acting upon advices from the Weather Bureau office in Grand Junction, a volunteer watchman would make the rounds of observing several thermometers on critical nights, and he would inform the engineer at the light plant whenever conditions warranted sounding the alarm.

Method of forecasting minimum temperatures.—Mr. E. S. Nichols had charted on large sheets of cross-section paper numerous observations of past seasons for each of the nine substations in the valley. One diagram for the relation between the hygrometric data at the Weather Bureau office and the ensuing minimum temperatures at the substation and another diagram for the relation between the maximum temperatures at Grand Junction and the ensuing minimum temperatures at the substation. (See samples, fig. 1.) The data used in the hygrometric diagrams were obtained by means of the formula $y=a+bR$, which has been explained several times in the MONTHLY WEATHER REVIEW,[2] especially the issues of August, 1917, and May, 1918, and the maximum temperature diagrams were prepared from the data of actual observations at Grand Junction and the substations.

[1] MO. WEATHER REV., May, 1918, pp. 213-228.
[2] See Supplement No. 16, 1919.

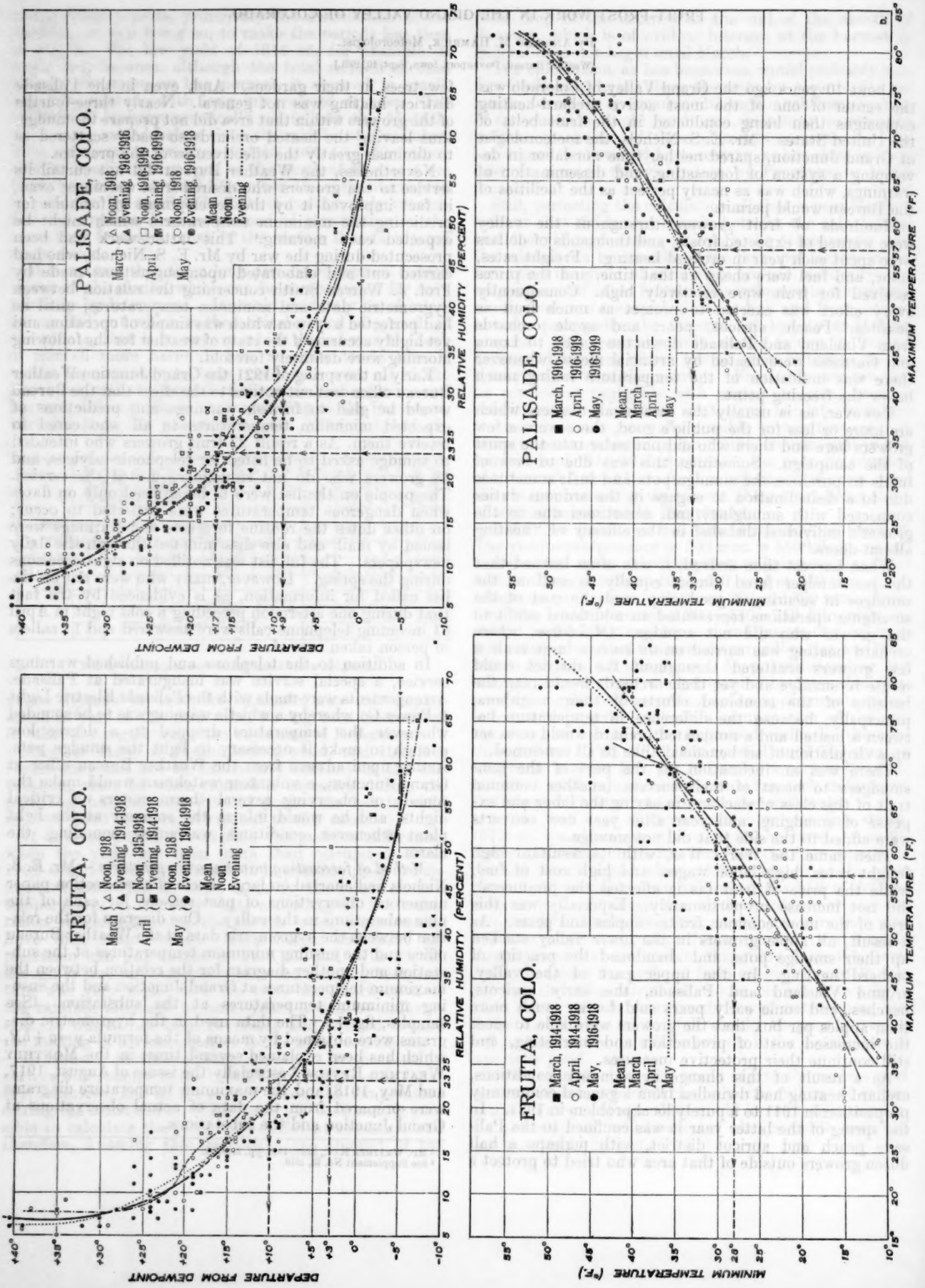

FIG. 1.—Maximum temperature and relative humidity relations at Fruita and Palisade, Colo.

Free-hand curves were drawn through the plotted observations to represent an average, rather than to use the smoother curves of the mathematical formulæ. In this way all the unexplainable variations and departures which occur in the data can readily be seen and considered, while in the curve drawn from a formula they are smoothed out. For instance, if a number of observations are "bunched" at a certain point on the diagram, probably as a result of some peculiar local condition not yet fully understood, the forecasters can incline toward this central point when his observation strikes the curve in its vicinity.

Different symbols were used for charting each month's data, and the forecaster can thus make allowances to each side of the curve to suit conditions best, and strike an even better average for a given month, or for a given decade in any particular month. Also, separate curves were drawn for the noon and evening observations; the noon data being charted in red ink and the evening data in black ink.

The preliminary advices, issued at 1:00 p. m., were based upon the regular noon observation and were, as a rule, conditional. That is, the growers were informed that the indications were for a minimum of, say, 28° at a certain station, "if the sky remained clear," etc. In making the evening predictions the forecaster had the benefit of the information which the evening weather map conveyed, and also the telegraphic advices from the district forecaster at Denver, to aid him in determining what the state of weather would be on the following morning.

The 1:00 p. m. advices were issued for the purpose of allowing the growers ample time to make all preparations during the afternoon and thus be in readiness to light their smudges should the evening predictions indicate such action necessary.

The predicted minima at 8 p. m. were usually the means of the three values secured from the hygrometric observations at noon, and at 6 o'clock, and the maximum which occurred during the afternoon. As an example, refer to the diagram for Fruita, Colo. (fig. 1, left). With a noon relative humidity observation of 23 per cent and a dew point of 17°, on a day in the latter part of April: Trace upward on the 23 line to the noon curve, as near as possible to the center of the group of *white squares,* go to the left from the noon curve and one finds the trace comes out at+10; adding 10 to the dew point, 17, gives a predicted minimum of 27° for the following morning. In like manner follow out the 6 p. m. observation: Relative humidity, 30 per cent; dew point, 25°. Going up the 30 line to the evening curve (center of black squares), and across to the left one finds +3, which added to 25 gives 28° as a probable minimum. The maximum temperature for the date in question happened to be 57° at Grand Junction. In the lower left of the same diagram the maxima at Grand Junction are charted against the following minima at Fruita. Going up the 57 line to the center of the April symbols (black squares), but inclining toward the center of the black dots because of the date being in the last decade of April, one finds that the line meets the curve at 28°. Averaging three values thus obtained gives a highly satisfactory result if clear weather prevails on the morning following the observations.

The same system, if carried out on the Palisade diagrams, gives an average of 34° for a predicted minimum at that station.

When cloudy weather is expected the forecaster must molify his predictions accordingly. In most cases, when there was a reasonable doubt about the state of weather, the forecasts were qualified by stating that "if the sky is clear at — a. m., the following minimum temperatures may be expected," and the smudgers were notified to set their alarms at the designated hour so they could arise and make an observation of the sky. If clear at the hour designated the forecasts could in variably be relied upon, and smudges were lighted; if cloudy, the smudger could again retire. That plan worked very nicely, and thus saved the growers as well as the Weather Bureau officials the inconvenience of remaining on guard throughout the night. In Palisade the volunteer watchman, previously referred to, made the observations of the state of weather at the designated hour, acting under instructions from the Weather Bureau office, and he attended to the sounding of the whistle alarm.

A form (Table 1) was printed on Map A, and each day the expected minima were computed for all stations by the different processes and entered thereon for convenience in answering telephone inquiries. The data for April 27, 1921, are given as an example. On the following morning the minimum temperatures and their departures from the predicted were entered, as were also the maxima at the substations. (It must be remembered that the substation maxima play no part in the formula, however. The cross-section paper diagrams are made from observations based on the relation between minimum temperatures at the substations and all other data at the Weather Bureau office in Grand Junction.)

TABLE 1.—*Substation reports, April 27, 1921.*

Frost?.	If clear, expect mean of (*a*, *b*, *c*) °F.	Station.	Expect— D. P. curve. Noon °F. (*a*).	D. P. curve. 6 p. m. °F. (*b*).	Max. Min. °F. (*c*).	Min. to-day. °F.	Difference. °F.	Max. yesterday. °F.
.....	29	Clifton	30	29	29	28	−1	56
.....	25	Fruita	25	24	25	25	0	60
.....	28	Fruitvale	25	23	26	28	(0)	58
.....	25						3	
.....	25	Hunter	27	24	25	26	1	52
.....	25	Loma	27	24	25	24	−1	65
.....	26	Orchard Mesa	28	24?	27	29	3	58
.....	[2] (27)	Palisade	32	(27)	(27)	31	0	53
.....	31			31	31			
.....	24	Pomona	25	23	25	26	2	53
.....	28	Redlands	28	28	28	26	2	56
.....	31	Office	32	30	32	31	0	55

[1] Add 3° because of change in location of station since curves were prepared. New location 3° warmer than old, as a rule. Station moved in December, 1920.
[2] At old station, now closed.

Effects of low temperatures during the spring of 1921.—The fruit growers experienced a most remarkable season during the spring of 1921. At the close of January the accumulated temperature excess was 200°; at the close of February it was 289°; and at the close of March, 472°. Below normal temperatures set in about March 24, and continued throughout April, the accumulated excess since the first of the year being +342° on April 30.

The relatively warm weather during January, February, and March forced the fruit buds so rapidly that by March 18 apricots were in full bloom and peaches were beginning to show the pink. According to many growers the date of apricot blossoming equals the early record for the valley, namely, the year 1910.

Freezing temperatures occurred several times after the fruit was advanced sufficiently to be endangered, but nearly always some unexpected meteorological condition

arose to offset the usual effects of low temperatures. On at least three different occasions rains and snows preceded the cold spells in the valley, and the condensation of a bountiful supply of aqueous vapor liberated enough latent heat to protect the crop.[3] In other instances a strong "canyon breeze" sprang up at the opportune time to mix the air and prevent much further cooling after dangerously low temperatures had been reached.

As an illustration of the narrow escape from total loss observe the following table showing minimum temperatures for March and April, 1921. After the 1st of May only one station reported a minimum temperature of 32° or below, and that station (Loma) was in the extreme lower end of the valley where little fruit is now grown.

Stations.	Lowest during month.			Stations.	Lowest during month.		
	March.	April.	May.		March.	April.	May.
	°	°	°		°	°	°
Clifton		23	37	Orchard Mesa		23	35
Fruita	19	17	34	Palisade	24	24	39
Fruitvale	20	25	35	Pomona	17	21	35
Hunter	18	21	36	Redlands	21	21	38
Loma	17	17	32	Grand Junction	23	28	38

The Smudging Committee's Report of 1912 sets the dangerous temperature lines for peaches as follows: Buds swelling, 15°; buds in the pink, 22°; full bloom, 29°; peach setting, 31°; dropping the shuck, 31°. For apples: Bud separating, 20°; bud in the pink, 25°; full bloom, 30°; fruit forming, 30°; petals dropping, 31°.

Since temperatures several degrees below these danger lines occurred during the period of development, it is remarkable that such an excellent crop of fruit is being harvested during the present season.

Other authorities[4] give somewhat lower critical temperatures than those above quoted, but there are so many factors aside from the actual temperature which enter into the freezing of fruit on trees that each locality is a problem in itself, and these values, arrived at through local study and experiment, perhaps apply best to the Grand Valley. For example, a temperature of 29° might seriously injure peaches when in full bloom in the arid climate of the Grand Valley and at an elevation of 4,600 feet, while at the lower elevation and in the more humid atmosphere of the Pacific coast the same fruit might withstand a temperature as low as 26°.[5]

When it was learned that, in several instances, severe freezes failed to materialize on account of an abundant supply of moisture in the orchards, a few growers experimented by spraying their trees with water instead of smudging on nights when freezing temperatures were indicated. The results were unsatisfactory, however, and later most of the fruit dropped from the trees which were sprayed. It was the intention to form a coating of ice around the fruit, thus holding its temperature at 32°, but failure was due, probably, to the fact that the experiment covered a too limited area, and the cooling effect of evaporation more than offset the warmth derived through freeing of latent heat in the process of ice formation. Moreover, ice can cool to below 32°, and if the fruit were not kept incased in ice throughout the entire period of low temperatures that night it was subject to more cold than would have been experienced under natural conditions.

A survey of the valley was made after the frost season of 1921, and it was learned that 29 growers in the vicinity of Palisade (representing a total of 200 acres) lighted their smudge-pots during the spring, acting upon advices sent out by the Weather Bureau office.

In the lower valley, where orchard heating has been discontinued, there seemed to be no further need for maintaining special meteorological stations, and therefore the special stations at Loma, Hunter, Pomona, Redlands, and Orchard Mesa, Colo., were closed on June 1, 1921. It is not thought that orchard heating will ever again be popular throughout the valley.

Over 900 carloads of Elberta peaches were harvested in the Grand Valley in 1921, and over 400 carloads of pears, notwithstanding the fact that the record of minimum temperatures which occurred during the season of blossoming would, at that time, have indicated a total loss.

In this connection it may be stated that it is highly probable that irrigation is playing an important part in making conditions better for fruit raising without artificial heating in the Grand Valley. Year after year since 1911 more land has been artificially watered. The relative humidity is thus increased over a large area, and this is favorable to the formation of local fog and clouds, and also to the liberation of considerable natural heat in the processes of condensation and frost formation. A map showing the Grand Valley appeared in the MONTHLY WEATHER REVIEW, for November, 1915, page 563.

DISCUSSION.

By E. S. NICHOLS, Meteorologist.

[Weather Bureau, San Jose, Calif., Sept. 24, 1921.]

Acting on suggestion by Mr. Hamrick, I am submitting the following remarks, not to controvert, but to supplement those made by him.

Even more than Mr. Hamrick does, I should emphasize economic conditions and results of experience in explaining the decline of orchard heating in the Grand Valley.

My first spring in the valley was that of 1911, at which time our fruit-frost service had been established only in a very informal manner. Orchard heating was at its height, though not by any means universal in the district. Unusually cold weather occurred during April; orchard temperatures as low as 15° and 16° were recorded in places on the 13th; and vigorous heating was practiced night after night.[6] Much fuel and labor was expended without evident adequate profit in the way of increased returns from the fruit crop, particularly in the apple districts. Consequently many growers in those districts failed to prepare to "smudge" during the season of 1912.

I thought that a revival of orchard heating would result from improvement in the Weather Bureau's forecasting and warning system and from better methods of heating and increase of knowledge regarding its results. In later years there were temporary revivals; but a combination of conditions prevented general resumption. For not only did the valley suffer from the general depression through which the fruit industry passed during several years, but, particularly in its lower sections, it had serious problems of its own. Also, experience has shown that, often a spring freeze kills only a portion of the fruit in an orchard,[7] and a full crop may be matured from a small percentage of the blossoms.

[3] "Cold air prevents severe freeze." MO. WEATHER REV., April, 1921.
[4] *Farmers Bulletin No. 1096.*
[5] See Nichols, E. S.: Damage by frost in western Colorado, MO. WEATHER REV., April, 1913, p. 608.

[6] See MO. WEATHER REV., Apr., 1911, 39:591.
[7] See MO. WEATHER REV., *Supplement No. 16*, p. 37, and Mr. Hamrick's report for 1921.

Thus the question of orchard heating became economic. Many fruit growers who believed in the operation in general were unable to raise money to buy fuel; while others found that heating did not pay under the conditions then existing in the valley. Thus, even before the World War many former "smudgers" had moved away or were compelled by force of circumstances to join the "slackers" referred to by Mr. Hamrick.

"Smudging" passed through two sudden declines; one immediately following 1911, the other due to effects of the war upon supply and prices of labor and fuel.

The above conditions were reported from time to time. Curtailment of the fruit-frost service was not recommended, however, because all of the substations were cooperative and their reports were gathered by telephone without additional expense. Valuable climatic data and experience, were secured by continuing the service intact. It is believed that all data and charts should be preserved for possible future use. All of the stations were found useful in connection with general crop reports and frost work, in both fall and spring.

It would seem that my article in SUPPLEMENT No. 16, MONTHLY WEATHER REVIEW, pages 38 to 45, should be mentioned in connection with description of charts and forecasting methods at Grand Junction.

RESULTS OF EVAPORATION OBSERVATIONS.

[Submitted by Robert E. Horton, Voorheesville, N Y., Oct. 12, 1921.]

These records were established and maintained by the Bureau of Plant Industry of the United States Department of Agriculture. Through an agreement between the officials having charge of these records and the Chief of the United States Weather Bureau, they have been compiled by Robert E. Horton in the form in which they are here presented.

The accompanying Table 1 shows the locations of the stations, their approximate latitudes and elevations, periods covered by the records, which were generally kept from April to September of each year, and also diameters of the evaporation pans.

Initially, some of the pans were 8 feet in diameter, while others were 6 feet in diameter. In most instances the larger pans were changed to 6 feet diameter at the end of the first year. The dates of change, if any, are shown in columns (5) and (6) of Table 1.

The pans were galvanized iron, 24 inches deep, buried 20 inches in the soil and kept filled with water to soil surface level or 4 inches below rim of pan. While there appears to have been some variations, yet the intention and the general rule was to maintain anemometer cups 24 inches above rim of pan. Mean air temperatures were obtained by taking the average of maximum and minimum thermometers in standard shelters, the thermometers being about 4 feet above ground.

Humidity was obtained by means of sling psychrometers.

The instructions required that grass should be kept cut and other obstructions removed from the vicinity of the pans so as to permit free wind movement close to the water surface. At many stations records of water-surface temperature were kept. The mean was obtained by averaging the daily readings of maximum and minimum thermometers. The thermometer tube was removed from the metallic backing and the glass stem slipped through a cork sufficiently so as to float the thermometer with its bulb about one-fourth inch below water surface. In the accompanying tables, mean air temperature is designated θ_a; mean water-surface temperature, θ_w; wind velocity, in miles per hour, w; vapor pressure, in inches of mercury, v; observed evaporation, in inches per month, E_0. In order to afford a basis of comparing the measured evaporation with the causal factors, a few interpolations of some of these elements have been made. Interpolated figures are inclosed in parentheses. There have been no interpolations of evaporation amounts.

TABLE 1.—*United States Bureau of Plant Industry evaporation records.*

	Station.	Record years used.	Latitude (approximate).	Elevation above sea level	Diameter of pan	
					8-foot beginning.—	6-foot beginning.—
			° ′	*Feet.*		
1	Aberdeen, Idaho	1913-19	42 40	4,400	.....	1913
2	Akron, Colo	1909-20	40 40	4,650	1909	1916
3	Amarillo, Tex	1908-19	35 20	3,676	1908	1910
4	Archer, Wyo	1914-20	41 00	6,012	.....	1914
5	Ardmore, S. Dak	1913-20	43 20	3,557	.....	1913
6	Biggs, Calif	1916-19	39 00	94	.....	1916
7	Big Springs, Tex	1916-20	32 00	2,396	.....	1916
8	Burns, Oreg	1914-19	43 40	4,125	.....	1914
9	Chillicothe, Tex	1913-19	34 20	1,406	.....	1913
10	Colby, Kans	1915-20	39 30	3,135	.....	1915
11	Crowley, La	1910-19	30 15	21	.....	1910
12	Dalhart, Tex	1908-20	36 20	4,000	1908	1917
13	Dickinson, N. Dak	1909-20	47 00	2,543	1909	1917
14	Edgeley, N. Dak	1908-20	46 20	1,468	1908	1917
15	Garden City, Kans	1908-20	38 00	2,836	1908	1917
16	Havre, Mont	1916-20	48 40	2,505	.....	1916
17	Hays, Kans	1907-20	39 00	2,000	1908	1917
18	Hettinger, N. Dak	1911-20	46 00	2,253	.....	1911
19	Lawton, Okla	1916-20	34 35	1,111	.....	1916
20	Mandan, N. Dak	1914-20	47 00	1,750	.....	1914
21	Moccasin, Mont	1909-20	47 15	4,228	.....	1910
22	Moro, Oreg	1911-19	45 40	1,800	.....	1911
23	Nephi, Utah	1908-19	39 45	6,000	1908 (Pan-4 diameter.)	..... inches'
24	North Platte, Nebr	1907-20	41 20	2,841	1908	1915
25	Sheridan, Wyo	1917-20	44 40	3,790	.....	1917
26	Tucumcari, N. Mex	1913-20	35 30	4,194	.....	1913
27	Williston, N. Dak	1909-16; 1918	48 00	1,875	1910	.....
28	Woodward, Okla	1914-20	36 30	1,900	.....	1914

TABLE 2.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Aberdeen, Idaho.					
1912.	°F.	°F.	M. p. h.		Inches.
June	63	64	8.4	.....	11.737
July	66	67	7.3	.....	12.882
August	63	61	7.0	.....	7.255
September	57	(57)	7.9	.....	5.337
Year	.....	.....	.....	.....	.....
1913.					
April	46	.....	7.4	.....	5.396
May	55	56	7.4	.....	6.926
June	61	64	5.2	.....	6.163
July	65	67	5.1	.....	7.316
August	69	67	4.7	.....	8.178
September	56	56	5.1	.....	5.653
Year	58.7	.....	5.8	.....	39.632
1914.					
April	45	.....	6.9	.....	4.190
May	53	.....	6.2	.....	6.853
June	58	.....	5.3	.....	5.677
July	70	.....	4.4	.....	8.084
August	67	.....	4.9	.....	9.268
September	56	.....	4.6	.....	4.443
Year	58.2	.....	5.4	.....	38.515

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_e.
Aberdeen, Idaho—Continued.					
1915.	°F.	°F.	M. p. h.		Inches.
April	51		5.5		4.959
May	51		6.2		5.160
June	57		6.7		7.903
July	65		5.4		8.988
August	70		3.9		8.192
September	55		5.6		6.032
Year	58.2		5.6		41.234
1916.					
April	46		6.8		5.228
May	48		7.6		6.471
June	58		5.9		8.080
July	69		5.1		9.658
August	65		4.3		8.335
September	57		5.0		6.657
Year	57.2		5.8		44.429
1917.					
April	40		7.0		3.244
May	49		5.8		5.046
June	60		6.8		8.813
July	71		4.6		9.780
August	65		3.8		8.562
September	59		4.3		5.380
Year	57.3		5.4		40.825
1918.					
April	43		7.1		5.317
May	51		7.2		6.895
June	68		4.9		8.279
July	68		3.9		7.779
August	63		4.4		7.828
September	59		3.7		4.808
Year	58.7		5.2		40.906
1919.					
April	47		5.2		3.695
May	56		6.5		7.306
June	63		4.8		7.040
July	71		4.8		10.494
August	69		4.7		8.838
September	59		4.7		4.521
Year	60.8		5.1		41.894
Akron, Colo.					
1908.					
April	51	(53.7)	8.7	(0.203)	4.740
May	55	(57.0)	8.4	(.246)	7.709
June	64	66	8.0	.341	7.639
July	70	72	6.0	.438	8.474
August	69	70	6.7	.398	7.826
September	66	62	7.6	.229	8.550
Year	62.5	63.5	7.6	.309	44.936
1909.					
April	42	(44)	9.0	.168	4.734
May	52	54	10.3	.210	6.825
June	64	69	6.8	.397	7.003
July	71	74	6.8	.459	9.396
August	72	73	5.8	.446	8.538
September	60	61	6.7	.310	5.857
Year	60.0	62.5	7.6	.332	42.353
1910.					
April	50	(50)	(7.5)	(.170)	6.387
May	53	(53)	8.1	.232	5.797
June	67	65	8.6	.354	8.722
July	74	75	6.1	.368	9.763
August	62	62	5.0	.408	7.142
September	63	65	6.0	.346	5.810
Year	62.3	61.7	6.9	.313	43.621
1911.					
April	47	(47)	9.1	.179	5.841
May	58	58	9.7	.241	7.323
June	70	71	7.4	.310	9.753
July	70	(70)	7.1	.355	9.774
August	69	(69)	8.1	.363	8.944
September	64	(65)	7.0	.295	7.183
Year	63.0	63.3	8.1	.290	48.818
1912.					
April	45		9.9	.326	
May	55		8.5		7.097
June	63		6.1		6.750
July	70		5.4	.476	7.618
August	69		5.0	.423	7.048
September	52		6.0	.271	4.645
Year	59.0		6.8		

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_e.
Akron, Colo.—Continued.					
1913.	°F.	°F.	M. p. h.		Inches.
April	47	54	8.1	0.171	4.330
May	57	62	6.9	.284	5.840
June	67	68	8.1	.329	8.180
July	72	71	6.1	.350	9.260
August	75	72	5.6	.345	9.310
September	57	58	6.4	.264	6.040
Year	62.5	64.2	6.9	.290	42.960
1914.					
April	45		8.7	(.200)	4.290
May	57	61	7.4	.295	5.608
June	68	71	5.8	.374	7.509
July	72	73	5.8	.426	8.654
August	71	70	6.5	.352	8.364
September	64	61	6.9	.269	7.438
Year	62.8		6.8	.319	41.863
1915.					
April	50	(54)	7.5	(.200)	4.220
May	52	56	7.7	.267	5.033
June	60	66	6.8	.371	5.883
July	67	70	6.2	.442	6.660
August	64	71	4.3	.438	5.961
September	60	63	6.4	.332	5.793
Year	58.8	63.3	6.5	.342	33.550
1916.					
April	44	(44)	8.1	(.160)	6.208
May	55	54	9.3	.183	7.811
June	64	65	7.4	.319	7.979
July	75	73	7.3	.359	11.116
August	69	72	5.4	.416	7.216
September	61	61	6.2	.237	6.836
Year	61.3	61.5	7.3	.279	47.166
1917.					
April	44		6.8	(.203)	4.081
May	50		8.5	.253	4.930
June	64		7.4	.313	8.424
July	73		5.5	.386	10.186
August	67		5.8	.364	8.464
September	64		6.0	.321	6.624
Year	60.3		6.7	.307	42.709
1918.					
April	40		10.4	.183	4.162
May	57		8.2	.230	6.780
June	72		6.4	.363	9.329
July	72		6.3	.419	9.252
August	70		5.1	.406	7.676
September	56		5.7	.279	4.283
Year	61.2		7.0	.313	41.422
1919.					
April	45		9.8	.191	4.951
May	55		7.6	.264	7.381
June	66		7.3	.358	8.756
July	75		6.4	.440	10.282
August	73		6.3	.330	9.718
September	65		6.1	.367	6.144
Year	63.2		7.2	.325	47.232
1920.					
April	36		9.9	.198	4.786
May	55		9.1	.325	6.840
June	61		6.1	.427	6.961
July	71		4.4	.476	8.582
August	67		4.7	.435	6.918
September	59		4.3	.322	6.825
Year	58.2		64.2	.364	40.912
Amarillo, Tex.					
1907.					
April	53	55		0.198	6.356
May	59	61		.288	8.050
June	71			.430	9.575
July	77			.543	10.609
August	76			.510	9.390
September	70			.387	7.911
Year	67.7			.654	51.930
1908.					
April	56	(54)	(10.10)	(.170)	7.318
May	64	62	8.5	.237	9.284
June	74	72	9.2	.435	10.378
July	73	74	6.3	.509	8.075
August	74	76	5.5	.518	8.575
September	67	68	5.5	.387	6.776
Year	68.0	67.7	5.8	.348	50.406

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_a.
Amarillo, Tex.—Continued.					
1909.	°F.	°F.	M. p. h.		Inches.
April	54	53	10.2	0.175	8.130
May	63	(62)	8.9	.217	10.020
June	73	(72)	8.6	.427	10.337
July	78	(79)	6.2	.524	9.904
August	78	75	5.8	.456	9.658
September	69	68	6.5	.315	8.421
Year	69.2	68.2	7.7	.352	56.230
1910.					
April	56	57	9.2	.175	8.494
May	60	62	9.4	.295	8.032
June	75	70	9.9	.356	12.011
July	78	76	7.8	.448	12.167
August	75	76	7.2	.523	8.806
September	73	70	7.5	.358	9.092
Year	69.5	68.5	8.5	.359	58.602
1911.					
April	55	53	10.1	.224	7.360
May	66	64	11.2	.359	10.109
June	76	72	8.5	.437	11.482
July	74	76	6.6	.532	7.4725
August	74	74	6.3	.433	8.895
September	73	71	6.5	.430	7.268
Year	69.5	68.3	8.2	.402	53.077
1912.					
April	55	(52)	10.2	.193	7.050
May	66	63	8.8	.231	9.895
June	69	70	7.9	.345	8.985
July	78	76	8.3	.436	10.947
August	75	75	7.6	.408	9.490
September	62	66	7.8	.354	6.493
Year	67.5	67.0	8.4	.338	52.861
1913.					
April	55	54	8.2	.196	7.736
May	68	65	8.0	.313	9.812
June	71	68	8.3	.486	7.005
July	80	72	9.0	.452	12.734
August	80	72	7.0	.408	10.453
September	63	66	6.6	.377	5.994
Year	69.5	66.2	7.8	.372	53.794
1914.					
April	55	55	11.4	.236	6.695
May	63	64	9.9	.391	6.739
June	77	73	10.1	.508	10.124
July	77	(73)	5.9	.529	8.747
August	74	73	6.6	.522	8.927
September	71	66	8.0	.412	8.041
Year	69.5	67.0	8.6	.433	49.273
1915.					
April	56	58	8.6	.293	4.584
May	60	64	8.4	.314	6.920
June	73	72	8.4	.410	8.833
July	75	74	8.2	.527	9.310
August	70	76	4.9	.504	7.299
September	68	70	6.8	.406	5.984
Year	67.0	69.0	7.0	.409	42.930
1916.					
April	52	54	9.6	.198	5.955
May	66	64	9.7	.256	10.286
June	73	68	9.3	.389	10.661
July	79	73	7.0	.408	11.656
August	76	71	8.0	.454	10.206
September	67	65	8.2	.383	7.665
Year	73.8	65.8	8.6	.348	56.429
1917.					
April	54	.....	10.7	.168	7.681
May	57	.....	9.2	.233	7.623
June	74	.....	9.6	.277	12.475
July	79	.....	9.2	.429	13.430
August	73	.....	7.0	.495	8.571
September	68	.....	6.1	.495	5.961
Year	67.5	.....	8.6	.350	46.170
1918.					
April	51	.....	10.4	.163	6.991
May	68	.....	12.3	.270	11.014
June	77	.....	7.8	.392	10.128
July	78	.....	8.3	.441	10.736
August	77	.....	8.1	.422	10.339
September	64	.....	8.2	.307	7.376
Year	69.2	.....	9.2	.332	56.584
1919.					
April	54	.....	8.7	.256	4.652
May	61	.....	5.8	.391	5.026
June	69	.....	5.7	.458	7.046
July	76	.....	7.9	.502	9.470
August	77	.....	5.7	.500	8.419
September	70	.....	7.1	.428	6.137
Year	67.8	.....	6.8	.422	40.790

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_a.
Archer, Wyo.					
1913.	°F.	°F.	M. p. h.		Inches.
April	.....	.....	.....	.....	.....
May	.....	.....	.....	.....	.....
June	61	61	7.9	0.309	7.104
July	66	63	6.5	.314	7.786
August	69	65	5.1	.335	7.557
September	55	53	5.8	.266	4.496
Year	.....	.....	.....	.....	.....
1914.					
April	42	(43)	9.5	.180	3.574
May	54	55	7.9	.230	5.703
June	63	64	7.5	.282	8.317
July	70	68	5.9	.348	7.987
August	67	65	6.1	.298	8.580
September	59	58	5.8	.237	6.774
Year	59.2	58.8	7.1	.262	40.935
1915.					
April	48	49	8.3	.231	3.160
May	48	(49)	8.6	.196	4.701
June	56	60	8.1	.284	5.557
July	64	67	6.2	.341	6.038
August	62	67	4.2	.344	5.352
September	55	57	6.5	.254	4.955
Year	55.5	58.2	7.0	.275	30.363
1916.					
April	41	.....	8.3	.148	4.529
May	50	.....	10.1	.187	6.158
June	60	.....	6.7	.271	7.572
July	71	.....	5.4	.308	9.061
August	65	.....	5.1	.359	5.945
September	56	.....	6.5	.238	6.347
Year	57.2	.....	7.0	.252	39.612
1917.					
April	38	.....	10.4	.161	3.765
May	44	.....	7.9	.209	3.431
June	60	.....	7.5	.249	7.288
July	69	.....	5.5	.343	8.317
August	64	.....	5.7	.295	6.988
September	60	.....	5.9	.249	5.560
Year	55.8	.....	7.2	.251	35.349
1918.					
April	35	.....	9.9	.158	3.683
May	52	.....	8.8	.187	6.297
June	65	.....	5.8	.340	6.842
July	66	.....	4.6	.376	6.077
August	66	.....	4.9	.337	6.909
September	53	.....	5.5	.267	3.712
Year	56.2	.....	6.6	.221	33.520
1919.					
April	43	.....	7.9	.222	3.877
May	53	.....	5.3	.236	7.875
June	64	.....	5.5	.261	8.490
July	70	.....	5.2	.373	9.250
August	68	.....	5.1	.280	8.291
September	60	.....	4.5	.306	4.877
Year	59.7	.....	5.6	.280	42.660
1920.					
April	31	.....	8.4	.149	3.174
May	49	.....	8.9	.252	5.588
June	58	.....	5.8	.302	6.137
July	66	.....	4.4	.388	6.510
August	63	.....	4.5	.320	6.316
September	58	.....	5.4	.237	5.358
Year	54.0	.....	6.2	.275	33.083
Ardmore, S. Dak.					
1913.					
April	48	(48)	6.8	(0.201)	5.697
May	55	65	5.9	.266	5.865
June	68	67	4.7	.420	7.467
July	72	70	6.3	.370	9.111
August	76	73	5.1	.395	9.516
September	61	61	6.5	.291	6.479
Year	63.2	64.0	5.9	.324	44.135
1914.					
April	45	(48)	8.2	.266	2.596
May	56	60	7.7	.286	6.045
June	66	71	7.1	.350	8.294
July	77	(78)	5.6	.375	9.861
August	70	68	5.6	.326	8.160
September	64	64	6.1	.255	6.821
Year	63.0	64.8	6.7	.311	741.82

TABLE 2.—Continued.

Month and year.	θ_s.	θ_w.	w.	v.	E_0.
Ardmore, S. Dak.—Continued.					
1915.	°F.	°F.	M. p. h.		Inches.
April	52	(55)	6.1	(0.201)	3.328
May	52	55	6.4	.270	4.381
June	59	67	6.5	.356	5.764
July	66	71	5.0	.430	6.082
August	67	74	3.3	.416	5.238
September	59	63	4.6	.416	4.115
Year	59.2	64.2	5.3	.330	28.908
1916.					
April	44	(46)	6.6	.245	3.853
May	52	55	8.1	.285	5.457
June	60	(64)	5.6	.398	6.090
July	74	(76)	4.2	.475	8.821
August	68	64	4.3	.416	6.903
September	59	(60)	5.3	.285	7.056
Year	60.0	60.8	5.7	.351	38.870
1917.					
April	41	.....	7.2	.186	3.592
May	49	.....	6.0	.266	4.471
June	62	.....	6.1	.314	7.816
July	74	.....	3.9	.375	9.702
August	68	.....	3.2	.340	7.871
September	61	.....	3.0	.296	5.809
Year	59.2	.....	4.9	.296	39.261
1918.					
April	39	.....	5.4	.171	3.166
May	54	.....	6.0	.239	5.747
June	68	.....	4.1	.341	5.983
July	70	.....	4.1	.463	6.969
August	70	.....	4.9	.401	7.903
September	55	.....	4.6	.288	4.765
Year	59.3	.....	4.8	.317	34.533
1919.					
April	43	.....	7.1	.196	3.997
May	55	.....	6.2	.266	6.257
June	68	.....	4.6	.408	6.457
July	75	.....	4.4	.448	9.268
August	72	.....	3.3	.357	8.687
September	63	.....	2.3	.261	5.958
Year	62.7	.....	4.6	.323	40.624
1920.					
April	35	.....	6.5	.141	2.830
May	54	.....	7.1	.276	4.544
June	63	.....	4.4	.392	5.043
July	71	.....	3.7	.425	7.098
August	69	.....	4.1	.360	7.575
September	61	.....	4.3	.299	5.992
Year	59.0	.....	5.0	.316	33.082
Biggs, Calif.					
1913.					
April	59	.....	.....	.....	4.223
May	68	.....	.....	.....	6.510
June	72	.....	.....	.....	9.078
July	80	.....	5.3	.....	11.142
August	81	.....	4.2	.....	9.347
September	75	.....	4.0	.....	8.208
Year	72.5	.....	.....	.....	48.508
1914.					
April	59	.....	3.8	.....	4.485
May	68	.....	3.8	.....	5.940
June	71	.....	5.5	.....	7.244
July	78	.....	4.3	.....	8.058
August	76	.....	3.4	.....	6.784
September	69	.....	4.7	.....	5.654
Year	70.0	.....	4.2	.....	38.165
1915.					
April	59	.....	5.2	.....	3.515
May	64	.....	5.1	.....	5.396
June	74	.....	4.4	.....	9.145
July	79	.....	3.0	.....	9.312
August	78	.....	2.2	.....	8.073
September	70	.....	3.1	.....	5.749
Year	70.7	.....	3.7	.....	41.190
1916.					
April	61	.....	4.6	0.353	4.930
May	63	.....	5.0	.329	7.201
June	72	.....	4.3	.409	8.981
July	78	.....	3.6	.479	9.905
August	76	.....	3.3	.514	8.392
September	72	.....	2.9	.422	5.921
Year	70.3	.....	4.0	.418	45.330

TABLE 2.—Continued.

Month and year.	θ_s.	θ_w.	w.	v.	E_0.
Bigg, Calif.—Continued.					
1917.	°F.	°F.	M. p. h.		Inches.
April	58	.....	5.2	0.311	4.223
May	63	.....	4.4	.334	6.173
June	75	.....	3.8	.374	9.605
July	83	.....	2.4	.465	10.213
August	77	.....	2.3	.483	7.999
September	72	.....	3.5	.433	6.178
Year	71.3	.....	3.6	.400	44.391
1918.					
April	58	.....	4.2	.309	5.485
May	63	.....	3.9	.336	11.086
June	80	.....	2.1	.424	11.952
July	77	.....	3.1	.458	8.502
August	76	.....	2.2	.477	7.019
September	69	.....	1.7	.543	3.880
Year	70.5	.....	2.9	.424	47.924
1919.					
April	60	.....	3.2	.339	4.432
May	68	.....	3.4	.439	6.482
June	73	.....	3.8	.431	8.991
July	79	.....	3.1	.532	9.692
August	77	.....	2.5	.523	7.828
September	71	.....	2.8	.470	5.527
Year	71.3	.....	3.1	.457	42.952
Big Springs, Tex.					
1915.					
April	.....	.....	.....	.....	.....
May	.....	.....	.....	.....	.....
June	82	77	8.0	0.576	11.494
July	81	79	7.2	.576	11.344
August	76	78	4.5	.539	8.153
September	74	73	5.8	.541	6.117
Year	.....	.....	.....	.....	.....
1916.					
April	61	59	8.2	.299	6.610
May	74	71	8.1	.357	10.838
June	83	78	8.8	.454	13.291
July	82	78	4.9	.515	10.435
August	79	74	6.6	.565	9.243
September	72	67	5.6	.470	7.714
Year	75.2	71	7.0	.444	58.131
1917.					
April	63	.....	9.7	.226	10.008
May	68	.....	8.7	.262	10.871
June	81	.....	8.6	.373	13.376
July	84	.....	8.0	.510	13.159
August	84	.....	6.7	.484	12.251
September	75	.....	5.6	.485	8.126
Year	75.8	.....	7.9	.390	67.792
1918.					
April	63	.....	8.8	.196	9.667
May	74	.....	9.3	.384	11.325
June	81	.....	5.1	.512	10.622
July	85	.....	5.9	.452	13.239
August	84	.....	6.0	.441	12.642
September	70	.....	5.8	.350	8.429
Year	76.2	.....	6.8	.389	65.924
1919.					
April	63	.....	6.9	.331	6.988
May	70	.....	5.1	.403	8.345
June	73	.....	4.3	.556	8.032
July	79	.....	5.4	.599	10.272
August	81	.....	4.5	.577	10.579
September	73	.....	4.5	.565	6.672
Year	73.2	.....	5.1	.505	50.888
1920.					
April	60	.....	7.0	.234	8.745
May	69	.....	5.4	.469	8.825
June	75	.....	5.4	.573	9.348
July	83	.....	4.4	.542	12.479
August	75	.....	4.3	.616	6.985
September	73	.....	3.7	.568	7.059
Year	72.5	.....	5.0	.500	53.441
Burns, Oreg.					
1914.					
April	45	.....	4.6	.....	3.472
May	54	.....	4.8	.....	6.487
June	56	.....	4.3	.....	6.647
July	67	.....	4.0	.....	9.860
August	66	.....	3.8	.....	9.405
September	53	.....	4.9	.....	5.532
Year	56.8	.....	4.4	.....	41.403

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Burns, Oreg.—Continued.					
1915.	°F.	°F.	M. p. h.		Inches.
April	48		4.7		4.352
May	49		5.6		4.971
June	55		5.1		7.714
July	62		4.0		8.820
August	69		3.4		9.036
September	52		4.1		5.871
Year	55.8		4.5		40.764
1916.					
April	45		5.2		4.632
May	45		6.7		6.269
June	53		5.0		6.905
July	59		4.5		8.225
August	64		3.5		7.393
September	54		3.6		5.837
Year	53.3		4.8		39.261
1917.					
April	40		5.7		2.919
May	48		6.0		5.309
June	56		5.2		7.895
July	69		3.8		10.190
August	57		3.6		5.457
September	47		2.8		3.647
Year	52.8		4.5		35.417
1918.					
April	42		5.7		5.104
May	48		6.3		7.186
June	65		4.4		8.611
July	65		4.3		8.657
August	59		3.1		7.257
September	57		2.3		4.674
Year	56.0		4.4		41.489
1919.					
April	48		6.7	0.207	4.509
May	54		7.6	.229	6.838
June	57		6.5	.184	8.435
July	67		5.5	.195	9.801
August	65		4.5	.214	8.210
September	54		4.6	.218	5.163
Year	57.5		5.9	.208	42.956
Chillicothe, Tex.					
1912.					
April					6.628
May					9.110
June	76		5.7	0.480	8.791
July	85		5.5	.601	10.687
August	82		5.4	.667	9.285
September	71		5.1	.533	7.019
Year					51.520
1913.					
April	62		7.8	.247	7.818
May	74		7.6	.393	9.758
June	77		8.0	.558	8.126
July	85		7.7	.535	11.547
August	87		5.3	.460	11.606
September	72		6.7	.467	6.397
Year	76.2		7.2	.445	55.252
1914.					
April	61	(60)	8.8		5.863
May	68	71	6.7		4.842
June	81	81	6.6		8.346
July	85	84	4.2		9.209
August	79	(76)	3.7		7.078
September	74	77	4.7		5.767
Year	74.7		5.8		44.105
1915.					
April	63	(62)	5.4	.387	4.307
May	68	71	5.8	.445	7.349
June	78	(75)	5.5	.624	7.307
July	81	80	5.5	.595	8.531
August	76	78	4.9	.610	6.929
September	75	74	5.4	.595	5.247
Year	73.5		5.4	.543	39.670
1916.					
April	58	(56)	9.9	.299	5.732
May	72	70	9.0	.409	8.729
June	80	77	9.3	.522	10.308
July	84	82	4.7	.547	10.719
August	84	80	6.3	.523	10.674
September	73	74	5.9	.463	7.072
Year	75.2	73.2	7.5	.460	53.234

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Chillicothe, Tex.—Continued.					
1917.	°F.	°F.	M. p. h.		Inches.
April	61	59	11.7	0.232	8.542
May	65	64	9.3	.297	7.636
June	80	73	8.5	.369	10.957
July	85	79	7.3	.530	11.758
August	81	77	6.2	.525	9.481
September	75	75	5.3	.501	6.959
Year	74.5	71.2	8.0	.409	55.333
1918.					
April	59	(58)	9.8	.232	7.455
May	75	69	11.0	.406	11.184
June	83	80	5.6	.539	9.663
July	85	79	6.4	.505	11.822
August	86	79	6.9	.457	12.984
September	70	71	7.0	.396	7.497
Year	76.3	72.7	7.8	.422	60.605
1919.					
April	60	62	8.5	.357	5.386
May	67	70	6.8	.487	5.680
June	75	(72)	5.2	.599	6.487
July	81	(78)	5.8	.632	8.383
August	83	(80)	5.0	.612	9.636
September	75	(76)	5.9	.559	7.239
Year	73.5	73.0	6.2	.541	42.811
Colby, Kans.					
1914.					
April	53				
May	60				
June	73	75	7.2	0.485	8.975
July	75	78	4.8	.557	7.972
August	75	74	5.9	.485	8.880
September	68	71	6.2	.357	7.592
Year	67.3				
1915.					
April	54	55	7.4	.309	4.023
May	55	57	7.6	.312	5.429
June	64	68	6.8	.468	5.843
July	71	74	5.5	.562	5.980
August	67	73	3.7	.507	5.444
September	64	67	5.5	.406	4.938
Year	62.5	65.7	6.1	.427	31.67
1916.					
April	46	49	8.1	.195	4.415
May	60	58	8.8	.246	7.065
June	67	68	7.4	.432	7.153
July	79	73	8.1	.466	11.231
August	75	69	6.8	.442	8.830
September	64	59	6.7	.311	6.838
Year	65.2	62.7	7.6	.349	45.532
1917.					
April	46		9.3	.194	4.362
May	54		8.8	.257	5.377
June	69		8.2	.336	7.950
July	77		6.3	.425	9.579
August	70		5.6	.456	6.741
September	66		5.5	.405	4.711
Year	63.7		7.3	.346	38.740
1918.					
April	44		10.3	.185	3.753
May	62		10.0	.289	7.049
June	75		6.2	.408	8.092
July	75		6.8	.469	8.457
August	77		7.0	.433	9.214
September	59		6.4	.295	4.810
Year	65.3		7.8	.346	41.375
1919.					
April	48		9.0	.241	3.540
May	57		7.1	.340	5.023
June	68		5.5	.504	6.607
July	76		5.9	.518	9.194
August	75		4.7	.446	8.857
September	69		5.0	.416	6.420
Year	65.5		6.3	.411	39.641
1920.					
April	43		9.5	.202	3.063
May	58		8.0	.348	4.064
June	68		6.4	.481	6.812
July	74		3.8	.511	7.504
August	69		3.4	.511	5.261
September	67				
Year	63.2				

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_θ.
Crowley, La.					
1910.	°F.	°F.	M. p. h.		Inches.
April	66	70	4.5		5.656
May	74	77	3.7		5.802
June	78	82	2.9		5.772
July	81	(84)	2.3		5.544
August	82	86	1.8		5.394
September	79	81	1.7		4.580
Year	76.7	80	2.8		32.808
1911.					
April	71		5.0		5.824
May	74		2.5		5.310
June	82		2.3		6.887
July	80		2.2		5.552
August	81		2.0		5.417
September	82		1.5		4.139
Year	78.3		2.6		33.129
1912.					
April	70		4.1		4.030
May	75		2.8		5.694
June	77		4.0		5.925
July	82		1.8		5.080
August	81		2.1		5.750
September	80		2.4		4.170
Year	77.5		2.9		30.649
1913.					
April	65		4.2		5.065
May	73		3.0		5.973
June	78		2.9		5.716
July	82		2.1		5.424
August	82		1.4		5.344
September	76		2.1		3.777
Year	76		2.6		31.299
1914.					
April	68	71	4.0		3.981
May	74		3.5		5.237
June	83	90	2.2		6.835
July	83	90	2.2		6.123
August	81	87	1.8		4.420
September	77	83	2.2		5.145
Year	77.7		2.6		31.741
1915.					
April	67	70	4.3		4.668
May	75	80	4.1		5.953
June	82	(87)	2.5		5.839
July	82	88	2.4		6.609
August	80	85	3.4		5.972
September	79	82	2.4		4.876
Year	77.5	82	3.2		33.917
1916.					
April	65	71	3.9		4.755
May	75	80	3.1		5.784
June	80	86	2.9		6.304
July	81	87	2.0		5.733
August	81	87	1.5		5.208
September	76	80	1.6		5.092
Year	76.3	82	2.5		32.876
1917.					
April	66	71	4.7	0.483	4.919
May	71	75	4.5	.504	6.533
June	79	86	2.5	.709	7.651
July	82	88	2.4	.859	6.022
August	81	88	1.5	.848	5.647
September	76	80	2.0	.680	4.835
Year	75.8	81.3	2.9	.680	35.607
1918.					
April	66	72	4.0	.531	4.180
May	74	81	3.7	.636	6.136
June	83	88	2.0	.827	6.695
July	82	88	1.2	.790	6.791
August	81	88	1.6	.874	5.709
September	73	80	1.9	.641	5.276
Year	76.5	82.8	2.4	.716	34.787
1919.					
April	67		3.4	.471	4.827
May	73		2.7	.617	5.423
June	79		2.6	.765	4.587
July	82		1.3	.874	5.245
August	83		1.6	.916	5.628
September	78		2.1	.760	4.886
Year	77.0		2.3	.734	30.596

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_θ.
Dalhart, Tex.					
1908.	°F.	°F.	M. p. h.		Inches.
April	53	(54)	(9.6)	0.284	5.920
May	61	61	10.1	.216	10.918
June	72	(72)	10.8	.310	12.072
July	72	73	7.9	.518	9.182
August	73	82	7.1	.536	9.888
September	66	67	6.5	.402	7.950
Year	66.2	68.2	8.7	.378	55.930
1909.					
April	50	52	11.2	.167	8.526
May	59	60	9.6	.232	9.901
June	72	73	8.7	.431	10.890
July	77	77	7.6	.465	11.685
August	76	76	7.7	.434	10.565
September	64	67	7.1	.325	7.835
Year	66.3	67.5	8.6	.342	59.402
1910.					
April	54	55	9.5	.173	8.540
May	59	59	9.3	.251	8.183
June	72	70	9.3	.335	12.020
July	78	75	6.8	.419	11.626
August	73	76	6.1	.470	8.822
September	70	69	6.7	.327	8.441
Year	67.7	67.3	8.0	.329	57.632
1911.					
April	54	54	9.9	.189	7.562
May	65	62	10.8	.321	9.900
June	78	70	8.8	.372	12.373
July	76	73	7.9	.464	9.707
August	75	71	7.1	.441	10.899
September	72	70	7.0	.373	8.769
Year	70.0	66.7	8.6	.360	59.210
1912.					
April	51	(52)	10.8	.196	8.214
May	64	(63)	9.0	.257	10.237
June	68	(67)	7.1	.379	8.475
July	77	(76)	7.3	.453	11.103
August	74	71	7.0	.497	9.131
September	61	(62)	7.4	.328	6.750
Year	65.8	65.2	8.1	.352	53.910
1913.					
April	53	51	7.4	.272	7.687
May	66	63	6.2	.517	10.063
June	75	72	3.7	.535	8.714
July	79	75	11.0	.552	12.697
August	79	77	7.4	.516	10.771
September	62	65	7.5	.432	6.338
Year	69.0	67.2	7.2	.471	56.270
1914.					
April	52	53	10.7	.251	6.535
May	61	65	9.0	.380	7.813
June	74	74	8.0	.470	10.256
July	74	79	4.1	.544	8.837
August	73	77	4.7	.468	9.059
September	70	71	6.2	.350	8.227
Year	67.3	69.8	7.1	.410	50.727
1915.					
April	56	(58)	6.8	(.219)	5.777
May	59	61	7.7	(.320)	8.075
June	70	73	6.6	(.426)	8.740
July	74	76	6.4	.612	9.262
August	71	76	4.5	.612	7.919
September	67	69	5.9	.480	6.853
Year	66.2	68.8	6.3	.445	46.626
1916.					
April	51	52	9.4	.273	6.597
May	64	63	9.8	.352	11.088
June	72	72	8.7	.452	10.367
July	78	76	6.9	(.513)	11.022
August	75	74	7.5	.498	9.597
September	67	68	7.5	.383	7.136
Year	67.8	67.5	8.3	.412	55.807
1917.					
April	52		11.0	.192	8.561
May	57		9.9	.241	9.074
June	72		9.6	.327	11.697
July	79		8.0	.480	10.997
August	74		7.0	.512	9.607
September	68		6.6	.453	7.460
Year	67.0		8.7	.368	57.396

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_θ.
Dalhart, Tex.—Continued.					
1918.	°F.	°F.	M. p. h.		Inches.
April	50	51	10.0	0.196	6.371
May	64	59	10.2	.335	10.640
June	75	70	6.5	.526	9.157
July	78	73	7.4	.600	11.229
August	76	67	7.0	.562	10.854
September	63	64	6.9	.328	6.318
Year	67.7	64.0	8.0	.424	54.569
1919.					
April	52	.....	8.9	.259	5.583
May	61	.....	7.5	.354	6.994
June	69	.....	6.2	.487	7.482
July	76	.....	6.0	.552	9.865
August	75	.....	3.8	.511	8.291
September	70	.....	5.4	.431	6.933
Year	67.2	.....	6.3	.432	45.148
1920.					
April	49	.....	9.7	.182	7.000
May	62	.....	7.4	.384	8.050
June	69	.....	6.3	.486	8.737
July	75	.....	4.7	.499	7.877
August	71	.....	6.9	.477	7.622
September	68	.....	6.6	.385	6.954
Year	65.7	.....	6.9	.402	46.240
Dickinson, N. Dak.					
1907.					
April	35	.....	.....	(0.188)	3.200
May	43	.....	.....	.172	4.765
June	56	.....	.....	.372	6.019
July	64	.....	.....	.430	5.886
August	64	.....	.....	.345	6.755
September	56	.....	.....	.256	4.008
Year	53.0	.....	.....	.294	30.633
1908.					
April	45	(48)	(8.2)	(.188)	3.300
May	50	(53)	(7.7)	.237	4.450
June	60	63	8.9	.334	5.898
July	70	72	4.9	.406	7.506
August	64	65	5.9	.314	6.844
September	60	58	7.0	.273	5.377
Year	58.2	59.8	7.1	.292	33.375
1909.					
April	36	(38)	(8.2)	(.188)	3.173
May	51	53	9.4	.251	4.922
June	62	66	7.0	.424	4.924
July	67	71	5.6	.498	5.360
August	68	71	4.9	.477	6.813
September	57	59	5.0	.321	4.326
Year	56.8	59.7	6.7	.360	29.518
1910.					
April	49	(53)	9.2	.189	5.422
May	50	54	8.0	.212	5.187
June	64	67	6.7	.373	7.007
July	69	70	6.1	.376	8.678
August	61	63	5.4	.328	5.665
September	54	56	5.0	.281	4.109
Year	57.8	60.5	6.7	.293	36.158
1911.					
April	39	(43)	8.0	(.188)	5.285
May	52	56	9.6	.247	5.794
June	65	69	7.3	.415	7.028
July	64	66	7.5	.292	9.259
August	60	63	6.4	.361	5.478
September	53	57	8.9	.290	3.597
Year	55.5	59.0	8.0	.299	36.441
1912.					
April	44	(47)	8.4	.188	3.650
May	52	55	9.6	.263	4.671
June	61	65	6.6	.380	5.528
July	65	71	5.6	.453	6.020
August	64	67	7.1	.417	5.922
September	50	53	7.1	.257	3.207
Year	56.0	59.7	7.4	.326	28.998
1913.					
April	46	.....	9.4	.....	4.147
May	50	.....	8.1	.....	3.978
June	63	.....	7.9	.....	6.951
July	65	.....	6.4	.....	7.211
August	69	.....	5.5	.....	6.882
September	56	.....	6.6	.....	4.701
Year	58.2	.....	7.3	.....	33.870

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_θ.
Dickinson, N. Dak.—Continued.					
1914.	°F.	°F.	M. p. h.		Inches.
April	40	(44)	8.8	.....	3.647
May	52	57	8.6	.....	4.434
June	61	67	7.0	.....	5.514
July	73	75	5.8	.....	7.604
August	63	68	4.8	.....	5.596
September	58	60	7.0	.....	4.344
Year	57.8	61.8	7.0	.....	31.139
1915.					
April	51	(53)	8.3	(0.188)	5.359
May	50	53	8.2	.258	3.626
June	57	63	7.7	.347	5.070
July	61	67	5.6	.443	4.731
August	64	69	3.3	.472	4.642
September	52	55	5.1	.337	3.200
Year	55.8	60.0	6.4	.341	26.628
1916.					
April	39	(39)	7.6	(.188)	3.160
May	50	49	9.4	.247	4.622
June	58	61	7.0	.347	4.412
July	71	77	4.6	.587	5.695
August	65	65	4.6	.405	5.246
September	55	(57)	6.8	(.284)	3.937
Year	56.3	58.0	6.7	.343	27.081
1917.					
April	36	.....	6.0	.212	2.139
May	49	.....	5.5	.215	5.826
June	59	.....	7.2	.319	7.141
July	72	.....	5.8	.411	9.179
August	66	.....	5.1	.334	7.165
September	57	.....	6.3	.279	5.229
Year	56.5	.....	6.0	.295	36.679
1918.					
April	41	.....	9.4	.182	2.852
May	52	.....	7.9	.252	5.759
June	64	.....	6.2	.407	6.430
July	67	.....	5.6	.422	6.701
August	67	.....	6.5	.427	6.641
September	53	.....	5.0	.283	3.979
Year	57.3	.....	6.8	.329	32.362
1919.					
April	44	.....	8.5	(.188)	4.321
May	55	.....	3.5	.363	6.728
June	71	.....	6.6	.405	8.853
July	73	.....	6.7	.348	9.876
August	70	.....	6.4	.324	9.058
September	60	.....	6.9	.289	5.793
Year	62.2	.....	6.4	.319	44.620
1920.					
April	33	.....	7.1	.133	2.855
May	52	.....	7.8	.257	3.441
June	62	.....	5.5	.409	4.919
July	67	.....	4.1	.483	5.852
August	68	.....	4.6	.363	6.942
September	57	.....	4.8	.261	4.033
Year	56.5	.....	5.7	.318	30.042
Edgeley, N. Dak					
1907.					
April	.....	.....	.....	.....	.....
May	46	51	.....	0.194	4.176
June	64	65	.....	.398	5.457
July	68	71	.....	.478	5.985
August	68	67	.....	.406	6.535
September	53	56	.....	.287	4.274
Year	.....	.....	.....	.....	.....
1908.					
April	.....	.....	.....	.....	.....
May	51	56	7.4	.275	4.445
June	61	65	8.2	.415	5.204
July	69	(72)	5.6	.466	7.037
August	65	67	6.5	.357	6.405
September	61	63	7.6	.355	5.530
Year	.....	.....	.....	.....	.....
1909.					
April	35	(37)	(9.1)	.132	3.390
May	52	54	9.7	.264	4.449
June	64	69	5.5	.478	4.193
July	67	73	5.7	.539	5.632
August	69	73	5.7	.517	5.856
September	58	61	6.3	.325	4.527
Year	57.5	61.2	6.9	.376	28.047

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Edgeley, N. Dak.—Continued.					
1910.	°F.	°F.	M. p. h.		Inches.
April	47	(49)	11.2	0.208	4.394
May	51	52	9.0	.212	5.809
June	67	65	6.9	.394	6.905
July	71	67	5.8	.394	8.254
August	64	62	6.7	.368	5.955
September	55	56	7.2	.340	3.779
Year	59.2	58.5	7.8	.319	35.096
1911.					
April	41	(43)	10.9	.180	4.637
May	56	59	8.9	.303	5.480
June	68	71	6.4	.454	6.534
July	67	68	6.9	.374	7.631
August	62	67	3.5	.438	4.670
September	54	59	6.3	.336	3.441
Year	58	61.2	7.1	.348	32.393
1912.					
April	45	47	7.4	.208	3.689
May	55	57	5.9	.326	4.598
June	61	66	4.6	.424	4.989
July	66	74	3.1	.542	5.688
August	62	68	2.9	.462	4.242
September	51	55	1.8	.342	2.744
Year	56.7	61.2	4.3	.384	25.950
1913.					
April	47	50	10.3	.213	3.631
May	52	53	4.6	.263	3.759
June	66	70	6.6	.463	6.356
July	66	71	5.0	.462	5.669
August	60	71	5.9	.488	5,528
September	57	59	5.2	.349	4.277
Year	59.5	62.3	6.3	.373	29.220
1914.					
April	41	(43)	8.8	.201	3.943
May	55	57	7.0	.300	4.823
June	62	68	5.4	.460	4.557
July	71	74	5.0	.578	6.736
August	63	66	4.9	.452	4.754
September	59	58	7.5	.365	4.376
Year	58.5	61.1	6.4	.393	29.189
1915.					
April	51	(53)	7.3	(.182)	4.330
May	49	53	8.5	.269	3.792
June	56	62	5.9	.384	4.467
July	62	68	4.4	.477	4.689
August	63	66	4.1	.454	4.833
September	55	53	6.4	.352	3.942
Year	56.0	59.2	6.1	.353	26.053
1916.					
April	39	(41)	9.3	(.182)	2.495
May	53	50	10.0	.267	4.839
June	58	58	5.8	.399	3.777
July	73	73	4.9	.687	5.814
August	66	63	5.2	.487	5.043
September	55	51	6.5	.334	3.594
Year	57.3	55.0	7.0	.392	25.562
1917.					
April	38	.....	7.0	.188	2.094
May	51	.....	6.5	.206	5.625
June	60	.....	7.0	.377	5.889
July	71	.....	5.5	.494	7.285
August	65	.....	6.3	.429	7.032
September	56	.....	6.7	.343	3.707
Year	56.8	.....	6.5	.340	31.632
1918.					
April	41	.....	11.0	.156	4.088
May	53	.....	8.8	.283	4.506
June	63	.....	6.0	.448	5.733
July	67	.....	5.4	.453	6.092
August	67	.....	5.9	.470	5.425
September	52	.....	4.6	.246	4.427
Year	57.2	.....	7.0	.343	30.271
1919.					
April	42	.....	9.2	.206	3.411
May	55	.....	8.9	.294	5.050
June	64	.....	7.1	.558	4.974
July	66	.....	5.4	.587	5.733
August	64	.....	5.6	.497	6.236
September	59	.....	6.4	.390	4.693
Year	58.3	.....	7.1	.422	30.097

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Edgeley, N. Dak.—Continued.					
1920.	°F.	°F.	M. p. h.		Inches.
April	33	.....	7.8	0.126	3.012
May	54	.....	8.1	.272	5.012
June	62	.....	4.6	.462	4.153
July	68	.....	4.1	.521	5.297
August	68	.....	5.8	.442	6.484
September	59	.....	5.2	.408	3.227
Year	57.3	.....	5.9	.372	27.185
Garden City, Kans.					
1908.					
April	54	(52)	(12.0)	(0.210)	9.022
May	64	61	11.6	.313	9.856
June	73	71	12.6	.479	10.496
July	76	75	8.5	.513	9.457
August	77	(77)	8.5	(.500)	9.689
September	71	67	8.0	.382	7.612
Year	69.2	67.2	10.2	.400	56.132
1909.					
April	50	(50)	(12.0)	.195	6.570
May	60	60	10.9	.255	9.097
June	72	71	8.5	.484	8.755
July	78	80	7.1	.615	9.801
August	80	(80)	6.9	.563	9.878
September	69	67	7.1	.391	7.462
Year	68.2	68	8.8	.417	51.563
1910.					
April	56	56	10.2	.256	7.755
May	58	62	9.4	.377	6.328
June	73	71	9.5	.455	9.425
July	78	76	6.6	.547	10.467
August	74	74	6.8	.568	7.627
September	69	69	7.4	.418	6.806
Year	68.0	68.0	8.3	.437	48.408
1911.					
April	53	56	11.1	.210	7.100
May	65	(65)	13.2	.356	9.723
June	79	(79)	9.7	.362	11.851
July	77	75	9.2	.518	10.252
August	76	74	9.1	.477	10.236
September	73	70	10.3	.413	8.859
Year	70.5	69.8	10.4	.389	58.021
1912.					
April	52	(50)	12.1	.217	6.796
May	65	61	11.6	.314	10.821
June	68	67	8.5	.440	8.576
July	78	74	7.9	.523	10.642
August	76	74	6.4	.511	9.151
September	63	61	8.4	.362	7.091
Year	67.0	64.5	9.2	.394	53.077
1913.					
April	53	55	12.3	.213	2.807
May	68	64	10.3	.306	8.228
June	73	69	10.4	.464	9.512
July	82	74	10.9	.445	14.153
August	82	74	8.1	.395	12.895
September	63	65	7.6	.367	6.930
Year	70.2	66.8	9.9	.365	54.525
1914.					
April	54	.....	11.1	.207	6.924
May	64	.....	10.3	.385	7.046
June	77	.....	10.3	.502	9.942
July	80	.....	5.9	.538	9.403
August	77	.....	7.4	.514	10.010
September	73	.....	8.8	.381	9.366
Year	70.8	.....	9.0	.421	52.691
1915.					
April	56	58	8.9	.329	5.252
May	58	62	9.5	.338	7.591
June	68	71	8.3	.505	7.701
July	74	74	7.2	.602	9.258
August	69	75	4.3	.532	5.920
September	67	71	6.7	.438	6.034
Year	65.3	68.5	7.5	.457	41.756
1916.					
April	49	(49)	9.7	(.210)	6.179
May	63	63	11.2	.268	9.631
June	71	72	9.8	.457	10.326
July	81	77	8.2	.469	13.218
August	77	76	7.2	.496	10.674
September	66	67	7.4	.365	7.431
Year	67.8	67.3	8.9	.378	57.459

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_θ.
Garden City, Kans.—Continued.					
1917.	°F.	°F.	M. p. h.		Inches.
April	50		11.3	0.222	6.564
May	56		9.5	.292	7.439
June	73		9.7	.376	12.317
July	79		7.3	.490	12.441
August	74		6.3	.532	9.009
September	69		7.2	(.400)	7.053
Year	66.8		8.6	.385	54.823
1918.					
April	47		11.3	.191	5.252
May	67		11.6	.309	10.252
June	77		7.3	.465	10.297
July	78		7.5	.513	10.117
August	80		7.5	.446	11.865
September	62		7.2	.332	6.328
Year	68.5		8.7	.376	54.111
1919.					
April	51		11.4	.261	5.256
May	61		8.8	.360	6.525
June	71		9.1	.471	8.620
July	79		9.2	.543	11.915
August	79		7.0	.498	11.083
September	73		8.1	.480	8.094
Year	69.0		8.9	.436	51.493
1920.					
April	48		9.9	.195	6.838
May	62		10.4	.396	7.408
June	72		10.1	.470	10.622
July	77		7.2	.518	11.156
August	71		6.2	.503	7.365
September	68		6.5	.417	7.314
Year	66.3		8.4	.417	51.199
Havre, Mont.					
1916.					
April	44		5.6	(0.159)	3.991
May	48		6.8	.235	5.493
June	58		5.7	.330	5.010
July	69		4.6	.440	6.427
August	66		3.7	.864	5.771
September	55		5.4	.291	3.866
Year	56.7		53	.303	30.558
1917.					
April	41		5.4	(.159)	2.578
May	53		5.4	.222	5.533
June	59		5.8	.259	6.091
July	71		4.5	.321	9.518
August	64		3.8	.332	7.033
September	56		3.9	.318	3.885
Year	57.3		4.8	.268	34.638
1918.					
April	41		5.6	.130	4.678
May	52		5.7	.164	6.118
June	68		5.3	.276	8.390
July	68		4.2	.319	7.311
August	66		4.8	.340	6.291
September	55		3.6	.238	3.685
Year	58.3		4.9	.244	36.473
1919.					
April	46		6.4	.188	4.314
May	56		6.1	.269	6.460
June	67		4.5	.327	7.659
July	72		5.0	.330	9.440
August	70		4.5	.344	7.646
September	55		5.6	.285	4.461
Year	61.0		5.4	.290	39.980
1920.					
April	35		7.0	.160	2.374
May	53		7.3	.230	6.889
June	61		5.4	.312	6.795
July	71		5.0	.414	8.210
August	68		4.7	.322	7.744
September	58		5.1	.246	4.973
Year	57.7		5.8	.281	36.985
Hays, Kans.					
1907.					
April	45	(44)		0.185	6.520
May	57	58		.305	7.199
June	71	73		.505	7.261
July	77	80		.614	8.612
August	76	74		.579	7.846
September	68	68		.401	7.210
Year	65.7	66.2		.432	44.648

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_θ.
Hays, Kans.—Continued.					
1908.	°F.	°F.	M. p. h.		Inches.
April	54	(53)	(11.5)	(0.220)	6.450
May	62	64	8.4	.363	7.181
June	70	74	8.6	.538	7.977
July	74	79	5.7	.581	7.967
August	75	77	6.4	.561	8.181
September	68	69	6.1	.445	6.625
Year	67.2	69.4	7.8	.451	44.381
1909.					
April	49	(48)	12.2	.208	6.370
May	61	61	10.8	.310	9.203
June	71	74	7.1	.586	7.211
July	76	81	4.7	.682	7.735
August	79	78	6.1	.576	10.215
September	66	68	6.0	.433	6.737
Year	67.0	68.4	7.8	.466	47.471
1910.					
April	55	53	10.1	.242	8.339
May	56	60	6.6	.369	4.855
June	70	70	6.4	.475	7.797
July	77	76	5.3	.570	9.258
August	73	74	6.5	.552	7.601
September	67	66	7.2	.453	5.969
Year	66.3	66.5	7.0	.444	43.817
1911.					
April	53	51	11.6	.216	6.564
May	65	62	13.2	.377	8.887
June	82	72	9.9	.401	13.981
July	81	75	8.1	.513	11.885
August	76	72	7.5	.508	10.274
September	73	68	9.5	.460	8.223
Year	71.7	66.7	10.0	.412	59.824
1912.					
April	53	51	11.9	.229	6.077
May	65	64	10.0	.380	8.284
June	69	69	6.5	.456	6.417
July	81	76	7.7	.540	9.987
August	78	75	7.7	.552	9.178
September	65	63	8.1	.369	7.022
Year	68.5	66.3	8.6	.421	46.965
1913.					
April	56	50	12.0	.276	6.610
May	65	63	8.8	.398	7.640
June	73	70	10.0	.531	8.530
July	82	74	10.0	.467	13.820
August	85	74	8.6	.413	14.450
September	64	64	8.0	.383	7.250
Year	70.8	65.8	9.6	.412	58.300
1914.					
April	51	52	9.8	.254	5.758
May	60	62	8.1	.429	5.094
June	75	74	8.6	.591	9.282
July	78	77	5.3	.562	9.256
August	77	73	7.2	.531	9.817
September	70	69	7.8	.455	7.889
Year	68.5	67.8	7.8	.470	47.096
1915.					
April	57	55	8.6	.344	4.486
May	58	62	8.3	.383	5.529
June	67	72	6.9	.528	5.328
July	72	76	5.7	.610	7.059
August	68	75	4.0	.552	5.381
September	67	69	6.3	.465	5.494
Year	64.8	68.2	6.6	.480	33.277
1916.					
April	49	54	9.1	.235	4.228
May	62	64	8.9	.353	7.037
June	69	73	7.2	.491	7.731
July	82	80	7.1	.527	12.201
August	80	76	8.3	.506	11.125
September	67	66	8.8	.390	7.909
Year	68.2	68.8	8.2	.417	50.231
1917.					
April	51		12.1	.210	6.354
May	57		9.4	.281	6.527
June	74		9.3	.385	11.069
July	81		7.4	.492	11.871
August	73		5.7	.504	8.140
September	69		6.3	.429	6.488
Year	67.5		8.4	.384	50.469
1918.					
April	46		10.0	.208	4.325
May	66		10.5	.388	7.491
June	78		5.9	.504	8.936
July	78		6.3	.542	9.062
August	81		7.0	.491	11.244
September	62		6.9	.299	6.511
Year	68.5		7.8	.405	47.569

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Hays, Kans.—Continued.					
1919.	°F.	°F.	M. p. h.		Inches.
April	50		10.2	0.282	4.065
May	59		6.5	.386	4.528
June	71		5.7	.582	5.405
July	80		7.2	.548	10.272
August	78		5.8	.502	9.344
September	72		7.8	.468	7.382
Year	68.3		7.2	.461	40.996
1920.					
April	47		11.0	.225	4.783
May	61		7.3	.434	4.682
June	72		7.5	.525	8.117
July	78		5.7	.624	9.646
August	72		5.5	.559	6.291
September	68		6.7	.449	6.257
Year	66.3		7.3	.469	39.776
Hettinger, N. Dak.					
1911.					
April	39	(43)	8.5	(0.200)	5.290
May	56	(61)	6.1	.255	7.222
June	70	63	8.8	.377	10.066
July	65	63	7.4	.274	11.011
August	63	59	6.9	.423	6.516
September	55	52	7.3	.329	4.458
Year	58.0	56.8	7.6	.310	44.653
1912.					
April	45	(49)	(8.2)	(.200)	3.940
May	53	(58)	10.1	.289	4.118
June	62	67	6.8	.345	6.236
July	66	72	4.3	.459	5.817
August	65	(65)	5.4	(.424)	5.999
September	52	(53)	5.8	(.380)	3.487
Year	57.2	60.7	6.8	.341	29.597
1913.					
April	46	(50)	8.6	(.200)	3.997
May	50	57	8.1	.228	4.368
June	64	68	8.7	.410	7.828
July	65	64	6.3	.421	7.772
August	68	66	5.5	.425	7.339
September					
Year					
1914.					
April	40		8.0	(.200)	3.585
May	51		9.1	(.271)	5.027
June	60		7.6	(.400)	5.961
July	71		5.8	(.460)	8.359
August	62		4.7	(.424)	5.835
September	60		6.1	(.330)	3.984
Year	57.3		6.9	(.348)	32.751
1915.					
April	51	(55)	8.1	.238	5.173
May	49	53	8.2	.278	3.743
June	56	64	6.9	.405	4.185
July	61	68	5.3	.445	5.061
August	63	69	3.5	.453	3.966
September	52	57	4.2	.331	3.367
Year	55.3	61.0	6.0	.358	28.495
1916.					
April	40	(44)	7.7	(.200)	3.947
May	50	54	8.5	.244	4.494
June	57	61	6.1	.347	4.146
July	72	76	5.0	.506	6.482
August	65	67	4.2	.434	5.270
September	54	56	5.0	.348	3.515
Year	56.3	59.7	6.1	.356	27.854
1917.					
April	36		9.5	.186	2.940
May	49		9.2	(.271)	5.545
June	61		9.9	(.400)	6.362
July	73		7.6	(.460)	7.677
August	66		6.4	.352	6.464
September	56		8.1	.280	3.618
Year	56.8		8.4	.325	32.606
1918.					
April	41		9.2	.233	3.354
May	53		8.2	.293	6.036
June	66		5.9	.446	7.701
July	67		4.4	.422	6.673
August	67		4.4	.460	6.744
September	54		4.0	.315	4.467
Year	58.0		6.0	.363	34.975

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Hettinger, N. Dak.—Continued.					
1919.	°F.	°F.	M. p. h.		Inches.
April	43		7.0	0.201	4.384
May	55		5.8	.316	5.886
June	70		5.7	.479	7.300
July	74		5.4	.508	9.175
August	71		5.2	.460	7.201
September	58		4.7	(.330)	5.101
Year	61.8		5.6	.382	39.047
1920.					
April	34		7.1	.140	3.362
May	53		7.9	.284	5.019
June	63		6.3	.437	5.189
July	70		3.7	.547	3.757
August	70		4.4	.421	7.308
September	57		4.8	.359	4.691
Year	57.8		5.7	.365	29.326
Lawton, Okla.					
1916.					
April	57	(57)	8.6		5.073
May	70	70	7.2		7.005
June	77	77	7.1		8.796
July	82	83	3.6		8.461
August	83	80	5.3		9.745
September	72	72	5.8		7.636
Year	73.5	73.2	6.3		46.716
1917.					
April	61		10.8	0.315	8.402
May	64		7.8	.381	7.310
June	77		7.0	.539	10.240
July	83		6.2	.607	10.064
August	80		5.2	.622	8.514
September	75		4.6	.531	6.495
Year	73.3		6.9	.499	51.025
1918.					
April	58		7.9	.276	6.138
May	74		9.6	.460	8.826
June	83		4.7	.632	7.999
July	84		5.8	.563	10.528
August	86		6.1	.546	12.132
September	68		5.3	(.577)	6.773
Year	75.5		6.6	.509	52.396
1919.					
April	59		6.7	.376	4.756
May	66		4.9	.502	5.405
June	74		3.3	.657	5.357
July	80		4.0	.734	7.183
August	82		4.6	.687	8.213
September	75		5.5	.582	6.103
Year	72.7		4.8	.590	37.017
1920.					
April	58		9.0	.273	7.048
May	69		5.5	.575	5.088
June	76		5.1	.637	7.647
July	81		3.8	.672	7.984
August	76		4.1	.670	5.236
September	74		4.7	.619	5.292
Year	72.3		5.4	.574	38.295
Mandan, N. Dak.					
1914.					
April	43	(45)	8.5	(0.182)	4.030
May	45	57	8.2	.356	5.680
June	64	68	5.5	.496	5.998
July	47	77	4.5	.606	7.550
August	65	68	4.4	.454	5.636
September	61	61	6.2	.371	5.055
Year	60.3	62.7	6.2	.408	33.949
1915.					
April	52	(54)	7.8	(.182)	4.850
May	51	53	7.3	.253	3.855
June	59	61	6.6	.374	5.377
July	63	67	5.2	.442	5.420
August	65	71	3.4	.449	5.467
September	55	59	4.8	.329	3.647
Year	57.5	60.8	5.8	.338	28.616
1916.					
April	41	(43)	7.3	.176	3.489
May	53	55	8.3	.227	5.505
June	59	63	6.1	.357	4.745
July	75	79	5.3	.605	7.411
August	67	71	4.1	.419	5.727
September	56	58	5.6	.291	4.400
Year	58.5	61.5	6.1	.346	31.277

TABLE 2.—Continued.

Month and year.	θ_s.	θ_w.	w.	v.	E_0.
Mandan; N. Dak.—Continued.					
1917.	°F.	°F.	M. p. h.		Inches.
April	38		6.1	0.186	2.183
May	52		5.7	.192	6.437
June	62		7.0	.312	7.175
July	73		5.5	.442	8.695
August	66		5.3	.360	7.021
September	57		5.6	.348	4.171
Year	58.0		5.9	.307	35.682
1918.					
April	42		9.3	.174	3.793
May	53		7.3	.251	5.510
June	65		5.6	.409	7.264
July	68		5.1	.411	7.226
August	68		6.0	.436	7.272
September	53		4.9	.243	4.434
Year	58.2		6.4	.321	35.499
1919.					
April	43		7.4	.192	3.739
May	56		7.0	.283	6.022
June	69		6.4	.482	7.258
July	74		5.4	.491	9.168
August	71		5.6	.430	8.057
September	61		6.1	.334	5.347
Year	62.3		6.3	.369	39.591
1920.					
April	35		6.7	.131	3.155
May	56		7.9	.264	5.543
June	66		5.7	.393	6.297
July	71		4.6	.477	7.157
August	71		5.3	.405	8.452
September	60		4.4	.335	4.647
Year	59.8		5.8	.334	35.251
Moccasin, Mont.					
1909.					
April	35			(0.185)	3.000
May	49			.212	4.657
June	58	52		.303	5.997
July	63	58		.385	7.222
August	65	59		.397	7.060
September	59			.273	4.671
Year	54.8			.292	32.607
1910.					
April	49		9.0	.187	5.176
May	51		6.8	.242	5.606
June	60		6.3	.307	7.208
July	68		5.9	.330	8.283
August	62		6.0	.287	7.382
September	53		6.4	.317	6.480
Year	57.2		6.7	.278	40.135
1911.					
April	38	(39)	7.8	.203	4.097
May	48	44	8.0	.271	5.941
June	60	56	6.4	.425	5.128
July	62	54	5.9	.378	7.312
August	58	(58)	5.9	.373	6.352
September	50	(51)	5.3	.265	3.412
Year	52.7	50.3	6.6	.319	32.242
1912.					
April	43		6.6	.239	2.618
May	52		7.6	.256	4.140
June	61		5.7	.394	6.394
July	61		4.3	(.330)	5.965
August	62		6.4	.311	6.231
September	48		6.7	.188	3.422
Year	54.5		6.2	.272	28.770
1913.					
April	43	(44)	8.7	(.185)	3.894
May	49	53	6.5	.238	4.229
June	65	66	5.3	.381	4.900
July	62	65	5.0	.341	6.366
August	65	66	5.4	.288	7.354
September	55	56	6.5	.225	4.583
Year	56.5	58.3	6.2	.276	31.326
1914.					
April	42		(8.1)	(.185)	3.208
May	51		7.5	.247	4.845
June	57		6.4	.332	4.431
July	68		5.5	.372	7.450
August	62		6.0	.289	7.239
September	56		7.2	.230	5.099
Year	56.0		6.8	.276	32.272

TABLE 2.—Continued.

Month and year.	θ_s.	θ_w.	w.	v.	E_0.
Moccasin, Mont.—Continued.					
1915.	°F.	°F.	M. p. h.		Inches.
April	50		7.6	(0.185)	4.697
May	49		7.5	.229	4.612
June	52		6.6	.282	4.345
July	58		5.1	.332	4.890
August	66		4.9	.358	6.505
September	49		5.9	.240	3.443
Year	54.0		6.3	.271	28.492
1916.					
April	41	(42)	8.1	(.185)	5.343
May	45	48	9.2	.173	5.261
June	55	57	7.7	.288	5.617
July	65	68	5.6	.382	6.893
August	62	63	5.3	.271	7.572
September	52	(53)	6.9	.208	4.841
Year	53.3	55.2	7.1	.246	35.529
1917.					
April	35		7.8	.163	2.486
May	46		7.6	.187	5.064
June	55		7.4	.240	6.057
July	69		5.9	.278	9.577
August	63		6.1	.240	9.873
September	56		7.1	.266	4.636
Year	54.0		7.0	.229	37.673
1918.					
April	37		8.9	.161	3.870
May	46		6.8	.200	
June	63		6.0	.311	6.761
July	63		4.5	.341	5.773
August	61		4.9	.302	5.654
September	53		4.9	.237	3.434
Year	53.8		6.0	.259	
1919.					
April	44		8.5	.159	4.685
May	52		8.0	.205	6.374
June	64		6.9	.278	8.568
July	68		6.6	.270	9.997
August	67		6.3	.253	8.742
September	54		6.7	.251	4.820
Year	58.2		7.2	.236	43.186
1920.					
April	32		8.8	.156	4.057
May	48		8.8	.191	5.361
June	57		5.4	.293	5.179
July	66		4.5	.365	6.066
August	64		4.8	.299	6.580
September	56		5.7	.218	4.793
Year	53.8		6.3	.254	32.036
Moro, Oreg.					
1911.					
April	46	47	9.6	0.158	5.924
May	51	53	9.2	.219	6.134
June	59	(59)	11.8	.258	9.614
July	70	67	9.4	.268	11.568
August	66	65	9.2	.287	9.275
September	53	55	7.2	.293	4.164
Year	57.5	57.7	9.4	.247	46.679
1912.					
April	46	48	8.4	.211	4.507
May	55	56	7.8	.254	6.751
June	62	62	5.9	.299	7.747
July	67	65	5.6	.318	7.894
August	64	62	5.3	.326	6.724
September	56	55	2.8	.249	4.496
Year	58.3	58.0	6.0	.276	38.119
1913.					
April	47		7.3		4.087
May	55		8.3		6.235
June	60		6.9		7.363
July	68		5.9		7.896
August	68		6.3		7.824
September	58		3.8		4.823
Year	59.3		6.4		38.228
1914.					
April	49		6.8		4.015
May	56		7.2		7.432
June	59		8.8		8.289
July	70		8.8		11.428
August	69		7.6		9.638
September	55		6.0		4.404
Year	59.7		7.5		45.206

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Moro, Oreg.—Continued.					
1915.	°F.	°F.	M. p. h.		Inches.
April	51		6.7	0.213	5.126
May	52		5.4	.308	5.895
June	59		8.2	.423	8.453
July	65		8.1	.436	9.054
August	72		7.6	.418	9.592
September	57		7.0	.314	5.300
Year	59.3		7.2	.352	43.420
1916.					
April	48		6.4	.216	4.797
May	50		6.6	.236	5.676
June	50		4.7	.305	6.801
July	62		4.5	.385	7.883
August	68		3.9	.382	7.499
September	59		3.6	.304	4.678
Year	56.2		5.0	.305	37.334
1917.					
April	44		7.8	.251	3.333
May	52		9.7	.289	5.768
June	58		7.8	.309	7.800
July	72		6.1	.342	9.698
August	71		6.8	.306	9.227
September	61		6.5	.332	4.418
Year	59.7		7.4	.305	40.244
1918.					
April	48		7.4	.198	5.500
May	52		9.6	.217	7.041
June	67		7.9	.303	9.482
July	69		8.4	.308	10.548
August	64		7.3	.319	7.243
September	64		4.6	.310	5.462
Year	60.7		7.5	.276	45.276
1919.					
April	49		6.9	(.212)	4.851
May	54		7.1	.231	7.105
June	60		7.8	.247	8.566
July	70		5.4	.300	10.578
August	68		5.0	.311	8.684
September	56		4.2	.282	4.167
Year	59.5		6.1	.264	43.951
Nephi, Utah.					
1908.					
April					4.800
May					6.980
June					7.879
July					10.543
August					9.341
September					6.234
Year					45.777
1909.					
April	43		4.7	0.203	3.645
May	52		4.6	.215	5.990
June	66		4.1	.260	8.803
July	72		4.1	.308	9.446
August	71		3.3	.382	7.036
September	59		3.7	.261	5.600
Year	60.5		4.1	.271	40.520
1910.					
April	49		5.3		5.822
May	56		4.6		7.451
June	68		5.4		10.898
July	73		4.4		9.979
August	71		4.4		10.082
September	62		3.9		6.008
Year	63.2		4.7		50.240
1911.					
April	44		4.3	.140	4.936
May	54		6.0	.151	8.403
June	63		4.9	.234	8.680
July	69		3.7	.280	8.702
August	70		4.4	.217	10.469
September	61		4.6	.211	6.695
Year	60.2		4.6	.206	47.885
1912.					
April	41		4.3		3.543
May	52		5.2		6.301
June	65		4.8		9.280
July	70		4.3		9.236
August	70		3.9		8.889
September	54		4.1		6.162
Year	58.7		4.4		43.411

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Nephi, Utah—Continued.					
1913.	°F.	°F.	M. p. h.		Inches.
April	(46)		(4.6)		5.934
May	58		4.6		7.474
June	63		4.4		8.313
July	70		4.2		9.526
August	71		3.5		8.252
September	58		3.3		5.250
Year	61.0		4.1		44.749
1914.					
April	46		3.7		3.235
May	57		3.7		6.440
June	62		4.0		7.277
July	69		3.1		7.409
August	72		3.3		9.520
September	62		4.4		7.767
Year	61.3		3.7		41.648
1915.					
April	52		4.2		4.311
May	52		4.0		4.735
June	60		3.8		8.424
July	70		4.0		11.153
August	71		3.3		10.644
September	58		3.3		6.247
Year	60.5		3.8		45.514
1916.					
April	48		4.9		5.395
May	51		5.0		7.793
June	62		4.4		10.021
July	71		3.8		9.392
August	68		3.7		8.923
September	61		3.9		7.428
Year	60.2		4.3		48.952
1917.					
April	42		3.8	0.167	4.030
May	48		2.5	.237	3.952
June	60		3.0	.218	8.208
July	74		2.9	.268	9.793
August	69		3.0	.229	9.172
September	61		2.8	.210	6.152
Year	59.0		3.0	.222	41.307
1918.					
April	44		4.1	.150	4.368
May	53		4.2	.182	6.700
June	71		2.9	.282	8.845
July	71		3.0	.317	8.754
August	69		2.8	.271	9.096
September	62		2.7	.230	5.902
Year	61.7		3.3	.239	43.665
1919.					
April	49		3.8	.221	5.051
May	57		3.7	.276	7.194
June	69		4.4	.251	11.365
July	77		3.6	.264	11.940
August	73		3.5	.252	9.369
September	63		3.8	.324	6.613
Year	64.7		3.8	.265	51.532
North Platte, Nebr.					
1907.					
April	43			(0.212)	6.447
May	52			.253	6.226
June	66			.414	7.785
July	72			.552	7.563
August	72			.457	7.703
September	61			.345	5.595
Year	61.0			.372	41.319
1908.					
April	51	(51)	9.4	.254	6.001
May	56	57	9.1	.308	6.992
June	65	67	8.1	.498	6.256
July	71	74	6.1	.610	7.513
August	70	72	7.1	.520	6.932
September	69	65	8.7	.355	8.242
Year	63.7	64.3	8.1	.424	41.936
1909.					
April	43	48	8.5	.170	4.626
May	57	57	9.4	.263	7.352
June	67	71	6.2	.505	6.123
July	72	76	6.9	.594	7.853
August	75	75	6.8	.599	8.341
September	63	63	6.7	.417	6.128
Year	62.8	65.0	7.4	.425	40.423

TABLE 2.—Continued.

Month and year.	θ_s.	θ_w.	w.	v.	E_θ.
North Platte, Nebr.—Continued.					
1910.	°F.	°F.	M. p. h.		Inches.
April	54	52	10.5	0.174	7.489
May	54	55	8.3	.304	5.976
June	68	(68)	10.6	.440	9,901
July	75	(74)	6.9	.532	9.747
August	69	(69)	6.8	.480	7.603
September	64	62	7.6	.384	5.848
Year	64.0	63.3	8.4	.386	46.564
1911.					
April	47	(47)	10.1	.202	5.699
May	60	58	10.5	.316	7.213
June	76	67	10.1	.452	12.485
July	72	69	7.8	.524	9.858
August	70	65	7.8	.554	8.093
September	66	64	7.6	.441	6.354
Year	65.2	61.7	9.0	.415	49.702
1912.					
April	48	(48)	9.5	(.212)	.....
May	60	58	9.5	.359	.....
June	66	63	8.0	.407	.....
July	74	72	7.0	.596	.....
August	71	71	5.8	.501	.....
September	58	55	7.0	.358	.....
Year	62.8	61.2	7.8	.406	.....
1913.					
April	51	.....	10.7	(.212)	6.662
May	59	.....	8.3	.366	6.626
June	70	.....	8.6	.496	9.219
July	75	.....	7.4	.517	10.386
August	79	.....	7.3	.561	11.558
September	63	.....	7.4	.402	7.005
Year	66.2	.....	8.3	.426	51.456
1914.					
April	50	(50)	8.3	(.212)	5.641
May	60	(60)	8.9	.358	6.324
June	72	72	7.6	.544	8.979
July	77	75	6.5	.610	10.147
August	74	69	6.7	.488	9.580
September	66	(66)	8.0	.379	6.765
Year	66.5	65.3	7.7	.432	47.436
1915.					
April	54	55	8.4	.290	6.108
May	54	56	7.4	.298	5.866
June	63	66	7.1	.444	6.040
July	69	73	5.5	.545	6.607
August	67	72	4.1	.494	5.981
September	61	64	6.5	.396	4.867
Year	61.3	64.3	6.5	.411	35.469
1916.					
April	47	47	7.5	.196	4.552
May	58	56	8.4	.287	7.015
June	64	65	7.9	.420	6.963
July	79	76	8.7	.533	11.028
August	73	74	6.0	.501	7.763
September	62	63	6.3	.367	6.282
Year	63.8	63.5	7.5	.384	43.603
1917.					
April	44	.....	9.2	.210	4.391
May	52	.....	8.8	.298	4.886
June	67	.....	7.5	.426	8.258
July	77	.....	6.0	.528	10.488
August	70	.....	5.7	.465	7.676
September	63	.....	6.6	.422	4.879
Year	62.2	.....	7.3	.392	40.578
1918.					
April	43	.....	10.1	.203	4.304
May	61	.....	9.5	.323	7.365
June	72	.....	6.7	.487	8.387
July	74	.....	6.2	.532	8.883
August	73	.....	5.6	.512	8.048
September	60	.....	5.8	.298	4.862
Year	63.8	.....	7.3	.392	44.849
1919.					
April	46	.....	8.7	.240	4.016
May	58	.....	7.6	.324	6.069
June	69	.....	7.9	.512	6.976
July	76	.....	6.2	.564	9.951
August	73	.....	4.7	.468	7.384
September	68	.....	5.2	.398	5.730
Year	65.0	.....	6.7	.418	40.126
1920.					
April	40	.....	8.7	.182	.....
May	58	.....	8.1	.340	.....
June	68	.....	5.8	.493	.....
July	74	.....	3.7	.444	.....
August	70	.....	5.0	.472	.....
September	65	.....	5.1	.358	.....
Year	62.5	.....	6.1	.382	.....

TABLE 2.—Continued.

Month and year.	θ_s.	θ_w.	w.	v.	E_θ.
Sheridan, Wyo.					
1917.	°F.	°F.	M. p. h.		Inches.
April	40	.....	5.9	0.187	.....
May	50	.....	6.4	.230	4.909
June	59	.....	5.2	.306	5.819
July	73	.....	4.3	.365	9.810
August	65	.....	4.2	.285	7.850
September	59	.....	4.4	.290	5.138
Year	57.7	.....	5.1	.277	.....
1918.					
April	38	.....	6.8	.191	2.948
May	52	.....	5.0	.245	4.181
June	68	.....	3.9	.411	6.368
July	69	.....	3.4	.419	6.694
August	68	.....	3.8	.340	7.503
September	56	.....	3.5	.288	3.873
Year	58.5	.....	4.4	.316	31.567
1919.					
April	46	.....	5.9	.184	3.563
May	57	.....	6.1	.213	6.899
June	71	.....	6.1	.283	8.976
July	75	.....	5.3	.314	10.297
August	72	.....	3.5	.287	8.770
September	60	.....	2.0	.310	5.158
Year	63.5	.....	4.8	.265	43.663
1920.					
April	36	.....	6.1	.185	2.100
May	52	.....	6.0	.303	4.128
June	61	.....	4.1	.396	5.255
July	69	.....	2.8	.443	6.754
August	68	.....	3.7	.312	7.152
September	58	.....	3.3	.245	5.083
Year	57.3	.....	4.3	.314	30.472
Tucumcari, N. Mex.					
1913.					
April	57	52	6.7	0.191	7.216
May	68	63	7.3	.292	10.345
June	71	69	7.2	.410	8.716
July	79	73	6.6	.400	11.833
August	79	72	5.2	.419	10.138
September	64	62	5.5	.332	6.438
Year	69.7	65.2	6.4	.341	54.686
1914.					
April	56	52	9.3	.221	7.046
May	64	62	7.4	.361	7.286
June	76	71	7.1	.470	9.875
July	76	75	3.2	.551	8.078
August	76	73	3.9	.487	8.962
September	73	68	5.0	.395	7.890(?)
Year	70.2	66.8	6.0	.414	49.137
1915.					
April	58	(54)	6.3	.286	5.554
May	63	60	7.1	.241	9.912
June	74	69	7.1	.342	11.239
July	76	71	6.1	.458	10.023
August	73	70	4.3	.441	8.406
September	70	62	5.6	.357	7.369
Year	69.0	64.3	6.1	.354	52.503
1916.					
April	55	50	7.6	.188	6.853
May	67	58	7.8	.187	11.317
June	77	66	7.6	.302	12.729
July	80	72	5.5	.390	11.506
August	76	74	5.5	.471	8.879
September	69	68	4.9	.351	7.617
Year	70.7	64.7	6.5	.315	58.901
1917.					
April	56	.....	8.7	.147	9.604
May	60	.....	8.2	.216	9.484
June	76	.....	7.3	.302	13.723
July	82	.....	6.4	.416	13.410
August	75	.....	5.4	.450	10.017
September	70	.....	4.4	.410	7.223
Year	69.8	.....	6.7	.323	63.461
1918.					
April	53	.....	8.7	.171	8.038
May	68	.....	10.0	.205	12.628
June	79	.....	6.7	.377	12.229
July	80	.....	6.8	.460	12.048
August	78	.....	7.0	.418	11.573
September	67	.....	6.9	.335	8.167
Year	70.8	.....	7.7	.328	64.683

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Tucumcari, N. Mex.—Continued.					
1919.	°F.	°F.	M. p. h.		Inches.
April	55		7.7	0.312	5.738
May	63		6.7	.456	7.784
June	70		4.7	.543	7.544
July	75		4.9	.573	9.205
August	77		2.9	.501	8.555
September	71		4.6	.467	6.962
Year	68.5		5.2	.485	45.788
1920.					
April	51		9.1	.174	8.101
May	64		6.2	.349	7.732
June	70		5.4	.450	9.213
July	76		3.8	.533	9.544
August	69		3.5	.526	7.330
September	61		4.1	.488	6.929
Year	65.2		5.4	.420	48.849
Williston, N. Dak.					
1909.					
April	35	(38)	(7.7)	(0.213)	3.000
May	51	(54)	(7.6)	.360	6.466
June	61	(64)	7.0	.453	5.173
July	67	(70)	5.8	.561	6.018
August	69	72	4.8	.467	7.254
September	59	61	5.1	.397	4.675
Year	57.0	59.8	6.3	.409	32.586
1910.					
April	50	52	8.7	.217	5.340
May	51	55	8.0	.236	5.764
June	67	68	7.0	.368	8.171
July	71	70	5.7	.402	8.994
August	62	62	5.5	.341	5.802
September	55	54	4.8	.273	3.910
Year	59.3	60.2	6.6	.306	37.981
1911.					
April	42	(45)	8.8	.182	5.790
May	56	54	8.6	.260	6.087
June	68	68	6.9	.416	7.145
July	65	67	6.1	.331	8.717
August	62	66	5.1	.376	5.624
September	53	54	6.0	.324	3.742
Year	57.7	59.0	6.9	.315	37,105
1912.					
April	45	53	7.2	.200	3.875
May	54	58	7.9	.282	4.781
June	66	68	6.1	.436	6.468
July	65	72	3.8	.460	5.980
August	64	69	4.6	.427	4.993
September	50	54	5.1	.268	2.981
Year	57.3	62.3	5.8	.346	29.078
1913.					
April	47	46	8.1	.218	4.432
May	52	55	6.5	.258	5.229
June	67	71	6.3	.431	7.676
July	67	70	4.2	.423	7.154
August	69	70	4.4	.460	6.737
September	57	57	5.1	.345	4.251
Year	59.8	61.5	5.8	.356	35.479
1914.					
April	43	51	6.6	.234	3.866
May	54	58	7.1	.287	5.603
June	62	67	4.9	.458	
July	73	77	3.5	.562	
August	64	68	3.5	.423	
September	58	59	4.2	.303	
Year	59.0	63.3	5.0	.378	
1915.					
April	52	52	7.3	.249	4.986
May	52	54	7.3	.268	5.073
June	58	62	6.9	.382	5.954
July	62	(71)	4.9	.400	5.793
August	67	70	4.0	.403	5.989
September	52	54	3.9	.311	2,659
Year	57.2	60.5	5.7	.336	30.454

TABLE 2.—Continued.

Month and year.	θ_a.	θ_w.	w.	v.	E_0.
Williston, N. Dak.—Continued.					
1916.	°F.	°F.	M. p. h.		Inches.
April	40		6.9	0.190	3.175
May	51		7.8	.263	5.153
June	59		5.9	.369	5.232
July	72		4.9	.548	6.828
August	64		3.7	.405	5.690
September	54		5.5	.294	3.862
Year	56.7		5.8	.345	29.940
1918.					
April	47	51	3.4		
May	53	56	2.5		
June	65	67	2.6		
July	68	71	3.0		
August	65	68	2.8		
September	55	56	1.3		
Year	59.0	61.6	2.6		
Woodward, Okla.					
1914.					
April	58	57	10.2	0.255	6.836
May	66	67	9.7	.445	6.237
June	81	78	11.0	.568	11.275
July	83	80	6.2	.574	(11.000?)
August	79	79	6.5	.584	8.940
September	75	73	7.9	.468	8.359
Year	73.7	72.3	8.6	.482	52.647
1915.					
April	60	(69)	9.4	(.264)	5.983
May	62	66	8.0	.377	6.729
June	73	(70)	7.7	.555	6.639
July	78	78	7.5	.633	10.038
August	72	77	4.1	.607	6.518
September	(71)	72	(6.4)	.562	5.755
Year	69.3	70.5	7.2	.500	41.662
1916.					
April	54	54	9.2	.254	5.931
May	69	(71)	9.1	.377	10.087
June	73	(70)	8.3	.650	8.248
July	82	(80)	5.7	.602	10.674
August	82	78	7.4	.538	11.111
September	70	69	8.2	.449	7.875
Year	71.7	70.3	8.0	.478	53.926
1917.					
April	54		11.5	.274	6.788
May	61		9.0	.314	6.979
June	78		9.4	.407	11.542
July	84		7.5	.542	11.715
August	76		5.1	.592	7.586
September	72		4.4	.515	5.254
Year	70.8		7.8	.441	49.805
1918.					
April	51		7.8	.237	4.971
May	71		11.1	.415	9.269
June	81		6.2	.554	8.608
July	81		6.4	.552	10.082
August	84		6.3	.511	11.001
September	66		5.4	.380	5.788
Year	72.3		7.2	.442	49.779
1919.					
April	57		9.5	.339	5.997
May	62		6.1	.452	5.358
June	71		5.1	.614	6.367
July	80		6.8	.649	10.690
August	83		6.1	.628	9.310
September	74		7.4	.529	7.599
Year	71.2		6.8	.535	45.321
1920.					
April	53		10.8	.227	7.699
May	66		7.6	.433	6.108
June	77		9.9	.537	10.415
July	80		6.1	.631	9.788
August	74		5.0	.604	6.867
September	72		6.6	.527	7.273
Year	70.3		7.7	.493	48.150

THE HURRICANE OF OCTOBER 25, 1921, AT TAMPA, FLA.

By EDWARD H. BOWIE, Supervising Forecaster.

[Weather Bureau, Washington, Nov. 28, 1921.]

Like many of the tropical storms of October that pass inland from the east Gulf of Mexico, the one under consideration had its apparent origin over the west-central Caribbean Sea. The first signs of the presence of this disturbance in that region were observed the morning of October 21, although relatively low pressure had been previously reported from bordering stations and from vessels authorized to send meteorological reports by radio. However, on the morning of the 21st when there were signs of the presence of a disturbance in that region, the following advisory information was broadcast:

Advisory 10 a. m. Disturbance appears to be forming over western Caribbean Sea southwest of Jamaica; movement uncertain, but probably northward.

At the time this advice was issued the barometer was high over the United States east of the Mississippi River, low along and off the east coast of the United States, and relatively high southeast of the Bermudas. As to the origin of the storm, little of an authoritative nature may be said, for meteorologists are not yet in agreement as to the forces which bring about their development. It is a matter that is still in the controversial stage. Nevertheless, we do know that they occur along the line of discontinuity which separates the two systems of trade winds—the northeast trades of the Northern, and the southeast trades of the Southern Hemisphere. Perhaps the hypothesis recently stated by Bjerknes to explain the origin of the extra-tropical cyclones will also be found to apply in the case of the tropical cyclones. In connection with the origin of the cyclone under discussion, the following letter from the Chief Hydrographer, Panama Canal, is interesting. It reads as follows:

Reference is made to cabled predictions of the West Indian hurricane of October 21–25. The service on this storm was as satisfactory to shipping here as that of the September 8 to 13, 1921, hurricane.

As usual, we were not detrimentally affected here locally. However, we did have a noticeable effect from it, considerably more than usual. I inclose barometric record, October 12 to 26 (not reproduced). You will note that our barometer, disregarding diurnal fluctuations, was steadily declining from October 13 to 18, preceding the birth of the hurricane. This period was accompanied by heavy daily rains, noticeably on the Pacific half of the Canal Zone; *winds prevailing from northward.*

On the 18th we had an unusual reversion to a more or less steady *southerly* wind of dry season intensity and with dry season characteristics except as for direction; virtually no rain; the above conditions obtaining to October 29.

During October 20–22, inclusive, wind movement averaged 19.4 miles per hour at Balboa Heights against a normal October movement of 6.4. That station had maximum five-minute intensities of 35 miles per hour.

Ships tell us of stormy voyages from San Francisco to Nicaragua contemporaneously with the passage of the Caribbean storm.

We infer from the foregoing that there had taken place previously to the birth of the cyclone fundamental changes in the primary wind régimé of the Tropics. What this had to do in bringing about the birth of the cyclone we do not know, but it is apparent that something more than purely local forces were in operation.

The diagram herewith gives the track of this cyclone from the time it first made its appearance in the Caribbean Sea up to the time it was lost over the Atlantic Ocean south of Bermuda. Up to the time the storm passed inland near Tampa, Fla., the track may be regarded as normal; after that time, decidedly abnormal, the change from normal to abnormal being brought about by the southward-flowing air from an extensive area of high pressure which moved southward from the Hudson Bay during the 25th to 28th. This southward-flowing air-stream controlled the movement of all pilot balloons released at pilot-balloon stations in the Atlantic States north of Florida during this period. This but confirms the opinion of the writer and others that the winds flowing out from and around anticyclones very largely determine the movement of tropical cyclones.

Passing north-northwestward from the position southwest of Jamaica, the cyclone passed near and to the east of Swan Islands on the morning of the 22d. The barometer fell to 29.20 inches, and possibly lower, at that station between 10 a. m. and noon and rose rapidly thereafter. During the afternoon of the same day the wind which had been from the north in the morning shifted to south-southwest and reached a speed of

FIG. 1.—Track of tropical hurricane, October 20–28, 1921.

80 miles an hour. Passing Swan Islands the cyclone reached the Yucatan Channel during the 23d, its center passing near Cape San Antonio, Cuba. It seems to have acquired its maximum intensity in this region, as the master of the schooner *Virginia* reported a minimum pressure of 27.80 inches when in the center of the cyclone. The S. S. *El Estero* while in latitude 25° 36′ and longitude 84° 24′, at 10 p. m. of the 24th, encountered the center of the cyclone, the barometer falling to 27.84 inches. The accuracy of the barometer aboard the *Virginia* is not known, but since the reading is not essentially different from the reading made by the observer at Tarpon Springs, near and north of Tampa, when the cyclone was passing inland north of Tampa, it is presumed to be approximately the true low barometer at the center of the disturbance. At Tarpon Springs the barometer as read by Mr. A. P. Albaugh showed a reading of 28.12 inches and at the same time the wind was a dead calm which lasted an hour or more, following 2:15 p. m. of October 25.

During the time that the cyclone was moving northward advisory information and warnings were issued to the threatened land and sea areas, and it is worthy of note that no report of loss of a vessel carrying radio outfit has come to the notice of the Central Office.

Hurricane warnings were ordered noon of the 24th for the west Florida coast from Key West to Apalachicola. The warning read as follows:

Change to hurricane warning at noon, Key West to Apalachicola. Increasing winds and gales and hurricane velocities along the coast. Emergency; warn all interests. Tropical storm near and northwest of west end of Cuba, moving slowly northward and will change its course to north-northeastward during to-day.

After crossing the Florida Peninsula the storm moved almost due east. The last information concerning it received by radio was supplied by the French S. S. *Montana* which came within the influence of the cyclone during the 27th-28th when in longitude 69° 14′ west and latitude 28° 22′ north. The lowest barometer recorded was 29.06 inches.

LOCAL DETAILS.

Local details of the storm, abstracted from reports by meteorologists H. B. Boyer, W. J. Bennett, and A. J. Mitchell, in charge of the Weather Bureau stations at Key West, Tampa, and Jacksonville, respectively, are given below.

METEOROLOGICAL CONDITIONS.

Key West, Fla.—Pressure slowly but steadily decreased from 29.92 inches at 10 a. m. of the 23d to 29.55 inches at 3:30 a. m. of the 24th, while the wind, moderate to fresh from the southeast during the afternoon of the 23d, steadily freshened throughout the 24th, veering from southeast to south between 4 and 5 p. m. and becoming strong. Between 6 and 7 p. m. the force increased to a moderate gale, and between 10 and 11 p. m. to a fresh gale, still blowing from the south. On the 25th the wind veered to southwest at 5 a. m. and 25 minutes later registered its highest velocity of 48 miles an hour. Thence on the force gradually diminished, and during the middle of the afternoon had fallen to fresh and had veered to west.

The rainfall throughout the passing of this storm was light and more or less intermittent, and while the gusty and squally character of the wind invariably accompanying tropical storms was present, this feature was not marked, but during one of these squalls, at 8:06 a. m. of the 25th, the extreme (1-mile) velocity was recorded—54 miles an hour from the southwest.

At the Sand Key station on the Florida reefs, 8 miles south of Key West, the maximum wind velocity recorded was 56 miles an hour from the south at 4 a. m. of the 25th, while the lowest barometric reading was 29.57 inches at the same time.

The heavy seas from the southeast, south, and southwest rolled in over the reef and practically washed away the island that had slowly built up since the hurricane of September, 1919. During the afternoon of the 24th the official in charge at Key West was informed by telephone that the seas were then coming within 5 feet of the recording rain gage. Instructions were given to remove the gage.

Although the employees at Sand Key were assured that violent winds need not be looked for, they were evidently quite nervous in view of the steady encroachment of the heavy seas, and to relieve this tension they were instructed to go to the lighthouse at their discretion. Immediately after the 8 p. m. observation they waded to the lighthouse, where they remained during the night, returning to the Weather Bureau building on the morning of the 25th.

Tampa, Fla.—On Tuesday, the day of the storm, hurricane warnings were ordered continued in the early morning, and distribution made as far as possible. Wires were already going down, but warnings of the previous day had been ample. Telephone and telegraph wires went down about noon, but the storm was near its height, and the office force was busy taking special observations, looking after the instruments, and giving information to anxious visitors who, in spite of the fury of the storm, continually filled the office and brought news of the damage and of the brave work of those who were assisting unfortunates to escape from the rising tide.

It began to rain about 4 a. m. Sunday, October 23, and continued with hardly a break until 9:15 p. m. of the 25th. The total recorded rainfall was 8.53 inches, but much more probably fell and was blown out of the gage. The barometer fell slowly at first, more rapidly after midnight of the 24th–25th, slowed down again between 5 and 7 a. m. and then fell still more rapidly until the minimum, 28.81 inches sea-level pressure, was reached at 2:45 p. m. The lowest previously recorded was 28.95 inches in 1910. After this it rose rapidly to 29.34 inches at 10 p. m. and then more slowly. The wind continued from the northeast during the 24th and the early morning of the 25th, increasing to 28 miles at 3:38 a. m. the early morning of the 25th. It shifted between northeast and east until 7:05 a. m., with velocity between 25 and 42 miles per hour. From 7:05 to 9:50 a. m. the wind was east, with velocity occasionally reaching 40 m. p. h. Southeast winds brought increased velocity, and when the wind changed to south about 2 p. m. it increased to 48 m. p. h. and reached a maximum velocity of 68 m. p. h. at 2:18 p. m. The extreme was 75 m. p. h. The wind had decreased to 30 m. p. h. at 3 p. m., but on the rise of barometer increased again, having shifted to the southwest at 3:10 p. m. The highest velocity with rising barometer was 48 m. p. h. The wind was west only 24 m. p. h. at 8 p. m. Occasional very high gusts occurred during the night, but the maximum did not again reach 30 m. p. h.

Tide on the 24th was 0.7 foot, falling at noon; 0.1 foot, falling at 2 p. m.; zero, falling at 4 p. m. During the night it rose and reached 3.6 feet, and rising at 8 a. m. Further reading could not be obtained, tide being over the tide-gage. The highest tide, however, reached 10.5 feet above mean low water at 2 p. m. as calculated afterwards by the United States Engineers. This is by far the highest ever recorded, the previous record being 5.55 feet.

Jacksonville, Fla.—Pressure distribution on the 21st over the Gulf and the South Atlantic States was such as to make the future course of the storm problematical, the preponderance of positive factors, however, rather favoring a northeast direction over Florida. This conclusion was shaken somewhat on the 22d when conditions seemingly favored a movement to the westward probably around the periphery of the HIGH, then over the East Gulf and South Atlantic States. The circulation at the morning observation of the 22d showed that the Gulf and lower South Atlantic sections were under the direct influence of the storm as it moved slowly northward, cloudiness having enveloped the lower coast line, with a perceptible increase in wind force at lower coast stations as the result of stronger pressure gradients.

The morning reports of the 23d pointed to a continued northward movement. Cloudiness featured all Gulf and lower South Atlantic stations with the rain area embracing practically all of the Florida Peninsula. The morning reports of the 24th showed falling pressure at all Gulf and South Atlantic stations, most pronounced, however, in Florida, with a fresh southeast breeze at Key West and south wind, force 4, at Habana. Night reports of the 24th accentuated the gravity of the situation and abundantly confirmed previous deductions by the Central Office relative to the future movement and intensity of the storm. Fresh breezes prevailed during the day along the northern coast line of Florida with moderate gales to the southward, attended by a 12-hour pressure fall of 0.22 inch at Key West.

The 24-hour rainfall at regular stations, ending at 8 a. m. of the 24th, was:

Station.	Rainfall (inches).
Key West	0.04
Miami	0.44
Titusville	4.26
Tampa	1.00
Jacksonville	0.14
Apalachicola	0.08

Twelve-hour pressure changes (all negative) for the period ending 8 p. m. of the 24th were:

Station.	Pressure fall (hundredths of inch).
Apalachicola	0.14
Jacksonville	0.12
Key West	0.22
Miami	0.12
Tampa and Titusville	0.12

An east-west line at the evening observation of the 24th, bisecting the State about Titusville, showed the wind to be east-southeast and south below, and northeast above, the line of demarcation.

The morning reports of the 25th were far from reassuring; in fact, they awakened a keener interest and a deeper concern by the public. Gales were blowing east of the Suwanee River, attended by torrential rains in much of the central and north-central portion of the peninsula. The night of the 24th–25th was altogether a wild one in the central and northern counties.

Barometer readings at 8 a. m. of the 25th, with 12-hour changes, were as follows:

Weather Bureau stations.	Sea-level pressure (inches).	Pressure fall (inches).
Apalachicola	29.66	0.14
Jacksonville	29.74	0.14
Key West	29.60	0.06
Miami	29.68	0.10
Tampa	29.30	0.44
Titusville	29.64	0.16

The 24-hour rainfall for the period ending at 8 a. m. was as follows:

	Rainfall (inches).
Weather Bureau stations:	
Apalachicola	0.08
Jacksonville	0.34
Key West	0.06
Miami	0.30
Fort Myers	3.30
Tampa	5.20
Titusville	3.02
Weather Bureau cooperative stations:	
Avon Park	5.05
St. Petersburg	5.05
Pinellas Park	7.81
Tarpon Springs	8.70
Brooksville	9.50
Ocala	5.67
Eustis	4.46
Clermont	5.00
McDonald	7.66
Sanford	3.60
Orlando	4.45
Glen St. Mary	4.10
DeLand	3.25
St. Leo	11.73

It will be seen that the greatest rainfall occurred near the path and over the upper-right front and the lower-right rear quadrants as the storm center approached the coast and progressed northeastward across the peninsula.

The usual calm prevailed at the center of the storm, one observer stating that "some blue sky was seen, then it (the wind) broke out from the west, blowing to beat the band."

The lowest barometer readings (mercurial barometers) occurred on the 25th and were as follows:

Station.	Lowest sea-level pressure (inches).	Time of occurrence (hour).
Fort Myers	29.37	Noon.
Jacksonville	29.35	Midnight.
Key West	29.55	5:25 a. m
Tampa	28.81	2:45 p. m.
Titusville	29.24	8:00 p. m.

The center of the hurricane passed inland just north of Tampa. Fortunately the American S. S. *Truxillo* was able to weather the storm and the master has favored us with the following log for the period midnight of the 24th to midnight of the 25th:

NOVEMBER 22, 1921.

Mr. WALTER J. BENNETT, Meteorologist,
Tampa, Fla.

DEAR SIR: In complying with your request of November 4, am herewith handing you the following. Clock times stated are ninetieth meridian time, or six hours behind Greenwich mean time.

Our position while in the storm center, as near as we can reckon, was approximately 24 sea miles due west of Egmont Key.

Oct. 24. 12 midnight. Bar. 29.62 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 4 a. m. Bar. 29.27 inches. Therm. 72°. Wind east, blowing force 11, Beaufort scale.

Oct. 25. 6.30 a. m. Bar. 29.00 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 8.00 a. m. Bar. 28.90 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 10.20 a. m. Entered storm center. Bar. 28.28 inches. No wind, but a terrific cross sea.

Oct. 25. 10.50 a. m. Passed out storm center. Bar. 28.28 inches. Therm. 72°. Getting wind from west, hurricane force. No wind throughout passage through storm center.
Oct. 25. 11.30 a. m. Bar. 28.32 inches. Wind west, hurricane force.
Oct. 25. Noon. Bar. 28.40 inches. Therm. 72°. Wind west, blowing hurricane force.
Oct. 25. 4 p. m. Bar. 29.02 inches. Therm. 73°. Wind west, blowing force 11.
Oct. 25. 8 p. m. Bar. 29.36 inches. Therm. 72°. Wind north, force 10, weather and sea moderating.
Oct. 25. Midnight. Bar. 29.48 inches. Therm. 71°. Wind north, force 9, weather and sea moderating.

The following barometer readings were taken Tuesday, Nov. 22, 1921, ship lying at Mallory Docks, Tampa, Fla., seventy-fifth meridian time:

8 a. m. Therm. 74°. Bar. 30.17 inches. Tampa station sea-level 30.15.
10 a. m. Therm. 76°. Bar. 30.19 inches. Tampa pressure sea-level, 30.17.
Noon. Therm. 78°. Bar. 30.14 inches. Tampa pressure sea-level, 30.13.
2 p. m. Therm. 78°. Bar. 30.12 inches. Tampa pressure sea-level, 30.09.

Hoping this information will be of benefit to you, I remain,
Very truly, yours,

C. S. HYERS,
Master S. S. "Trujillo."
By S. STANTON,
Chief Officer.

High tides, October 25.—Tampa: The tide was 10.5 feet, the highest since 1848. Egmont and Sanibel Island: Both were practically covered by water. Fort Myers: Tide was 12 to 18 inches higher than previous records for 30 to 35 years. Punta Gorda: Tide was 7 feet above normal high tide at 3 p. m. of 25th; water was in the streets of the city. Punta Rassa: Tide was 6 feet above normal high water. Boca Grande: Tide 5 feet 4 inches above normal high tide at 7.15 a. m. Clearwater: Tide 5 feet above normal high tide, 1.30–4 p. m. St. Petersburg: Tide 8 feet 5 inches above mean low water at 2 p. m.

Maximum wind velocities, with date and direction: Key West, 25th, 48 miles SW. Jacksonville, 25th, 64 miles NE. Mayport, 25th, 54 miles SW. Tampa, 25th, 68 miles S. Tarpon Springs, Dunedin, Egmont Key, and Safety Harbor, all near the center of the storm, estimated the wind velocity as being 80 to 100 miles an hour.

Loss of life.—So far as known the loss of life was small—not exceeding five or six—due, no doubt, to the fact that shipping remained in port.

Loss of shipping.—One coast steamer, the *Vann*, plying between Jacksonville and Miami, foundered off the Jupiter coast about 10 a. m. of the 25th. The value of the vessel and cargo was about $120,000. Several schooners are reported to have capsized off the coast, but definite information is lacking.

Intrastate loss.—The citrus crop sustained a loss 800,000 to 1,000,000 boxes of fruit, approximating a monetary loss of more than $1,000,000. The loss of trees was not great; in fact, the damage from that source was slight. Truck crops adjacent to the coast were greatly damaged—a complete loss in many instances. And the loss of fertilizer and labor greatly augments the disaster, totaling, no doubt, $1,000,000 or more. Salt water flooded many acres, thereby rendering the soil unfit for cultivation in some instances; heavy rain will, however, soon remove the salt deposit, restoring the soil to normal condition.

Miscellaneous damage.—The damage to residences, docks, warehouses, buildings, bridges, and miscellaneous property, at Tampa, Tarpon Springs, St. Petersburg, Sarasota, Punta Gorda, Marco, Caxambus, and Fort Myers; in short, along the coast from a point near Cedar Keys, southward, will exceed $1,000,000, and the aggregate of losses will probably total $3,000,000. The damage on the east coast, while considerable locally, was altogether of little moment when compared with that which befell the west coast.

THE ELECTRICAL CHARGE OF THE ATMOSPHERE AND THE HEIGHT OF THE BAROMETER.

By W. J. HUMPHREYS.

It has been suggested that many cyclones and anticyclones may be caused by changes in the electrification of the outer atmosphere, such changes, for instance, as presumably occur at the times of brilliant auroræ. It is proposed to check this suggestion by a simple calculation.

Let any considerable, more or less circular, horizontal extent of the upper air be uniformly electrified to the equivalent of a surface charge of density ρ units of electricity per square centimeter, and let the earth immediately beneath have an equal charge of opposite sign.

Now, if there is no other disturbing electrification, the force f on a unit quantity of electricity anywhere between the earth and air charges (assuming, as is approximately true, that the direction of the electric force is everywhere vertical) is given by the well-known equation

$$f = 4\pi\rho$$

of which half is from the air charge and half from the earth charge.

Hence the total electrical pull P between the air and the earth is given by the expression

$$P = 2\pi\rho^2 A \qquad (1)$$

in which A is the area of the charged surface of the earth.

From the value of f, it follows that the work w necessary to carry a unit charge through a difference of level h within the full electric field is

$$w = 4\pi\rho h,$$

or, substituting for ρ its value in terms of P and A, equation (1),

$$w = 4\pi h\sqrt{\frac{P}{2\pi A}}.$$

Hence

$$\left(\frac{w}{h}\right)^2 = 8\pi\frac{P}{A} = 8\pi p \qquad (2)$$

where p = dynes pull on each square centimeter of the electrified surface of the earth, or upper air.

But w/h = ergs work on an electrostatic unit of electricity per its centimeter change in level.

Now, the normal, vertical potential difference in the atmosphere is about one volt per centimeter. Hence, converting to electrostatic units, and substituting in (2),

$$\left(\frac{1}{300}\right)^2 = 8\pi p,$$

or

$$p = 1/2{,}261{,}947.$$

But the weight of one cubic centimeter of mercury at 0° C., and under normal gravity

$$= 13.5951 \times 980.665 \text{ dynes}$$
$$= 13{,}332.24 \text{ dynes}.$$

Hence p equals the weight of a column of mercury 1 square centimeter in cross section and 1/30,156,820,271 centimeter, or, say $1/(3\times10^9)$ millimeter, high.

That is, a local electrification of the outer atmosphere sufficient to produce a potential difference between it and the earth, having an equal charge of opposite sign, of 1 volt per centimeter difference in level would increase the height of the mercurial barometer about $1/(3\times10^9)$ millimeter.

If, however, the outer atmosphere were charged to this extent over all the earth, each square centimeter of it (regarded as a charged surface) would be repelled radially outward by the rest of the charge on the shell with the force F given, as is well known, by the equation

$$F=4\pi\rho^2.$$

Hence, from (1), per square centimeter of the charged surface,

$$F=2P.$$

That is, if the upper air is charged to the extent supposed, all around the earth, the mercurial barometer will stand *lower* by the same amount it would stand *higher* in response to an equally dense local charge, namely, in the present case, by $1/(3\times10^9)$ millimeter.

But, as an extreme case, let the charge be local, as first assumed, and let the potential difference with change of elevation be 30,000 volts per centimeter, a value far in excess of any observed except occasionally, perhaps, during the passage of a thunderstorm. With this extreme local electrification the barometer would be raised only about 3/10 millimeter.

Obviously, therefore, no appreciable portion of those considerable changes in atmospheric pressure, giving differences in the readings of the barometer of, say, 2 to 3 centimeters, characteristic of the passage of cyclones and anticyclones, can logically be attributed to variations in the electrification of the upper air, whether at the times of auroras or at any other time. Hence, it seems extremely improbable that either cyclones or anticyclones are ever produced by changes in the electrification of the outer atmosphere.

PRESSURE MAPS AT THREE KILOMETERS IN JAPAN.

By S. FUJIWHARA.

[Central Meteorological Observatory, Tokyo, Japan, Sept. 19, 1921.]

NOTE.—A paper by S. Nakamura in the February, 1921, number of the *Journal of the Meteorological Society of Japan* entitled "Upper air currents and volcanic ashes from Asama" contains a reference to the practice, in Japan, of drawing maps of pressure at the 3-kilometer level. Dr. S. Fujiwhara, who devised the method, was asked if he would not kindly explain it for the benefit of those in this country who might be interested. The following interesting account of the method has been received in response to this request.—EDITOR.

Our primary object in drawing the upper isobars was to learn their forms and to get the direction and the relative intensity of the upper wind. We noticed first that the error for the pressure at any level lower than 4,000 meters that arises from the inaccurate estimation of the intermediate temperature is not serious, and also that what we want most is the general trend of the upper isobars, but not the absolute values of the pressure at the level concerned. For the general trend, the errors themselves do not produce much disturbance, but the differences, which are by no means so great, of errors for pairs of adjacent stations might come into effect. For example, suppose the errors for all stations lie within the limits of 8.5 and 11.5 mm. Then the mean error of 10 mm., being common to all, makes no disturbance in the general trend of the isobars at that level, which is actually affected by errors of ±1.5 mm., which, for practical purposes, can be overlooked.

We began to draw upper isobars for our daily weather service in March, 1919, following the principle of Ferrel and Bigelow; by applying several artifices of our own and also that of Köppen, we arrived at an idea that the most useful isobars of the upper layers are those between 3,000 meters and 4,000 meters, so far as the vicinity of the Japanese Empire is concerned. We found by experience also that for the weather service quickness and simplicity of the process are preferable to precision.

The simplest way to draw isobars for the 3,000-meter level from the data at the earth's surface is as follows:

(1) Take the figures of pressure in millimeters of mercury, reduced to sea level and to the freezing point of water and add them to the figures of air temperature in centigrade at the same station. For example:

Reduced barometric reading	752.4 mm.
Reduced air temperature	24.1 °C.
Sum	776.5

(2) Enter the figures thus obtained into a chart and draw isopleths just as isobars. These lines are approximate isobars at the level of 3,000 meters.

By this method we get the general form and trend of the isobars at 3,000 meters, from which we can get also the idea of the direction of the wind there prevailing and also its relative intensity; because, as Sir Napier Shaw has already shown, the direction of the upper wind is nearly always tangential to the isobars at that level. From the distance separating consecutive isobars we can guess the relative intensity of the wind. We do not know, however, the absolute value of the pressure for each isobar, because the figures obtained above are only relative ones. As already has been shown by Mr. S. Takayama, we can get the approximate value of the pressure in millimeters by dividing the figures by 2.

Why do such figures give the relative values of pressure at the level of 3,000 meters? The reason is simple. We can easily see that the middle value of pressure difference corresponding to the difference of 1 mm. at mean sea-level is nearly 0.67 mm. For the range of pressure variation at mean sea-level, 730 to 780 mm., the deviation of the actual value of the pressure difference from the above mean value of 0.67 mm. is less than 0.03 mm., which is negligible for practical work. The pressure difference at 3,000 meters corresponding to a difference of 1° C. in the mean temperature of the air column from sea level to 3,000 meters is also nearly 0.67 mm., and the deviation from this value according to the temperature variation is also not great. This accidental coincidence of the pressure difference at the level of 3,000 meters due to pressure and temperature variation at the earth's surface enables us to make the above artifice.

* * * * *

Expressed mathematically,

$p_3-P_3=(0.67+\alpha)\epsilon+(0.67+\beta)\theta_m$ in which, p_3 is the current pressure at 3 kilometers, P_3 the mean pressure at that level, ϵ the difference between current and mean pressure at sea-level, θ_m the difference between current and mean average temperature of the air column, and α and β two small quantities representing variations from 0.67 mm., as a result of the range of pressure and temper-

ature, respectively. As shown above, $\alpha\epsilon$ and $\beta\theta_m$ are negligibly small, so that,

$$\begin{aligned} p_s - P_s &= 0.67\ (\epsilon + \theta_m) \\ &= 0.67\ (p_0 - P_0 + t_m - T_m) \\ &= 0.67\ (p_0 + t_m) - 0.67\ (P_0 + T_m) \\ &= 0.67\ (p_0 + t_m) - \text{a constant.} \end{aligned}$$

This holds if the lapse rate is uniform. When the lapse rate is not uniform, we ought to make some allowance for it so that

$$p_s - P_s = 0.67\ (p_0 + t_m + \tau) - \text{a constant.}$$

For our purpose τ can be obtained by rough estimation. From the results of the actual observation of the upper air temperature we can make a table for τ corresponding to various circumstances; e. g., fair weather, rainy, near the surface of discontinuity, morning, evening, summer and winter, continental, oceanic, etc.

We compared the isobars thus constructed with those obtained by the ordinary methods and found good agreement between them. Dr. Nakamura's short memoir also shows the availability of the method.

DISCUSSION.

By C. LE ROY MEISINGER.

It may occasion some surprise to discover that it is really possible to add pressure to temperature at the surface and obtain pressure in the free air. But, as Dr. Fujiwhara says, this is being done every day in Japan. Since the making of pressure maps in the free air is of considerable interest in connection with certain barometry problems in the United States it will be instructive to point out one or two features which may be pertinent to the application of a similar device here.

The level at which a certain increment of pressure at sea-level produces the same effect as a certain increment of temperature applied to the mean temperature of the air column, is given, neglecting the effect of vapor pressure, by the equation:

$$h = 18400 \log \left(\frac{B_0 + \Delta B_0}{B_0}\right) \frac{[1 + \alpha(2\theta + \Delta\theta) + \alpha^2\theta(\theta + \Delta\theta)]}{\alpha\Delta\theta},$$

in which B_0 is the pressure at sea-level, α is 0.00367, the coefficient of gas expansion, θ the mean temperature of the air column, ΔB_0 and $\Delta\theta$ the increments of pressure and temperature, respectively. If, for example, we substitute for B_0, 760 mm., and for θ, 0° C., and for ΔB_0 and $\Delta\theta$, 1 mm. and 1° C., respectively, we obtain 2,818 meters as the value of h. This is the situation assumed by Dr. Fujiwhara; and, since only the horizontal pressure gradients are of interest, it is accurate enough to designate the reduction level as 3,000 meters. If millibars were used instead of millimeters, the level at which pressure and temperature effects are equal is 2,164 meters. Hence, if the Japanese map were drawn in millibars, the reduction level should be approximately 2,000 meters. In this manner any convenient combination of values of ΔB_0 and $\Delta\theta$ may be used. In the ordinary use of the hyspometric equation it is easy to lose sight of this interesting relation.

Would this method be useful in the United States? The answer lies in the difference between the behavior of the small term τ which Dr. Fujiwhara has inserted in his last equation. If the lapse rate is uniform, a difference of 1° C. at the surface would mean a change of 1° C. in the mean temperature of the air column; and, under such conditions, one would be justified in adding temperature to pressure. But when the lapse rate is not uniform, and that is most of the time, it is necessary to correct our sum by the value τ, which depends upon a number of factors, as shown by Dr. Fujiwhara.

Japan is a small country relative to the United States. Its area is about that of the State of California. Moreover, it is surrounded by extensive ocean areas, and its climate is consequently maritime. It is natural that temperature changes at the surface and aloft should not depart markedly from those characteristic of the ocean. In other words, the free-air temperature distribution should be steady and uniform, and thus should tend to diminish irregularities of τ, consequently rendering the method more reliable.

But in the United States, the situation is quite different. The extensive continental area produces strong seasonal variations between inland and coastal regions; and the elevation differences between the east and west, the extremely variable nature of the surface covering, and topographic irregularities, result in a complex of temperature conditions that would make it difficult, if not impossible, to tabulate, as they do in Japan, the probable variation from the uniform lapse rate.

Again, the pressure conditions are more regular above Japan than above the United States. Our country lies in the path of storms moving in from the North Pacific and the result is a pressure situation quite variable from one part of the country to another owing to its great extent. This, combined with the irregular temperature effects mentioned above, would probably effectively militate against the use of such an artifice in this country.

NOTES, ABSTRACTS, AND REVIEWS.

INTERNATIONAL METEOROLOGICAL COMMITTEE.

[Reprinted from *Nature* (London), Oct. 6, 1921, pp. 194-195.]

The first meeting, for general purposes, of the international committee appointed by the conference of directors of meteorological institutes and observatories held in Paris in 1919, in continuation of the committees which have organized international meteorology from the Congress of Vienna in 1873, was held during the week September 12-17 in London. Those attending as members were Sir Napier Shaw (president), M. A. Angot (vice president), Prof. E. van Everdingen (secretary), Col. F. A. Chaves, Director Hesselberg, Commandant Jaumotte, Dr. Maurer, and Capt. Ryder; as presidents of commissions, Prof. Bjerknes (Bergen), of the Commission for the Study of the Upper Air; Col. E. Gold, of the Commission for Weather Telegraphy; and Col. Saconney, of the Commission for Aerial Navigation; and, as savants whose assistance would be useful in the deliberations of the committee, Col. Delcambre, Dr. Gorczyński, Col. Matteuzzi, Dr. Melander, Prof. T. Okada, Dr. G. C. Simpson, Dr. A. Wallén, Dr. S. Fujiwhara, and Mr. L. F. Richardson.

The business opened with the election of two members of the committee—Director Wallén, of Sweden, to fill the sixteenth place, which was left vacant at Paris, and Prof. T. Okada, of Tokyo, in succession to Prof. Nakamura, of the same institute, resigned. It concluded with the election of Col. Delcambre, director of the Office Météorologique National of France, and Dr. G. C. Simpson, director of the Meteorological Office, London, to the places vacated at the end of the meeting by M. Alfred Angot, Directeur Honoraire du Bureau Central Météorologique, and by Sir Napier Shaw, now Professor of Meteorology in the Royal College of Science, under the rule which requires the 16 (ultimately 20) members of the committee to belong to different countries and to be directors of independent meteorological institutions.

Apologies for absence were received from Prof. Eginitis, of Athens; Mr. H. A. Hunt, of Melbourne; Prof. Nakamura, of Tokyo; Prof. Palazzo, of Rome; Sir Frederick Stupart, of Toronto; and Dr. G. T. Walker, of Simla.

The chief business of the meeting was to receive reports from the commissions for special departments of meteorological work. Of these, two—namely, the Commission for the Study of the Upper Air and the Commission for the Meteorology of the Polar Regions—had met in Bergen in the last week of July of this year. The Commission for Weather Telegraphy had held a meeting in London in November of last year to formulate new codes for the transmission of information, from land stations and from ships, respectively, in pursuance of certain provisions of the peace treaty. That commission held further meetings in the week ending September 10 of this year for the discussion of details in the light of experience already obtained. In the same week meetings were held of the Commission for Maritime Meteorology, for Aerial Navigation, and a joint meeting of the three commissions concerned with the speedy transmission of meteorological information was held to consider points of common interest. Meetings of the Commission for Réseau Mondial were also held.

The chief recommendations discussed were: (1) By the Commission for the Study of the Upper Air, inviting observations of the upper air from land and sea and proposing to resuscitate the practice of preparing and issuing an international publication of the results for the upper air contributed by the various countries, and to obtain subventions for the purpose of providing for the cost of compilation and editing, as well as of printing and distributing. The total annual sum required was estimated at £4,000. (2) By the Commission for Weather Telegraphy, setting out an agreed code for land stations and, jointly with the Commissions for Maritime Meteorology and Aerial Navigation, two alternative codes for ships at sea, between which a selection should be ultimately made so that one form of message shall become universal. (3) By the Commission for Maritime Meteorology, proposing suitable cooperation for the collection of oceanographical data. The formulation of the codes and the approach to a final solution of the questions involved are a matter for warm congratulation.

The Commission for the Réseau Mondial recorded its thanks for the volumes which the British Meteorological Office had already published, and expressed a desire for their continuance. At the same time the question of daily charts for the globe was raised, and Col. Matteuzzi urged the daily issue of reports of pilot balloons with the object of obtaining a general view of the streams of air.

On the initiative of Col. Delcambre, a new commission was set up for the further study of clouds; and on the initiative of Col. Saconney it was recommended that rewards should be offered for valuable observations, notes, or photographs spontaneously contributed by aviators and others.

Prof. Okada, on behalf of Prof. Nakamura, urged the industrial and economic, as well as the scientific, importance of a speedy publication by all institutes of a summary of the weather month by month.

Some time was devoted to the question of the application of meteorology to agriculture, and the commission appointed at Paris for that study was enlarged by the addition of a number of names of experts on the agricultural or biological side of the various subjects involved. It was also decided. that application of the study of weather to forestry should be included.

The report of the Polar Commission dealt with the provision that had been made at Obispo, Spitsbergen, Bear Island, Jan Mayen, Lerwick, and in northern Canada and elsewhere, for geophysical investigations during Amundsen's proposed drift across the Pole. It was decided to unite the Polar Commission with the Commission du Réseau Mondial. Dr. Simpson was appointed president of the united commission.

At the meeting on September 15 Col. F. A. Chaves, of the Azores, well known to all meteorologists for his enthusiasm for the subject, announced that the Portuguese Government had appointed Sir Napier Shaw, M. Angot, and Prof. E. van Everdingen to the dignity of Commander of the Order of Santiago da Espada in recognition of their services to international meteorology, and that he expected to be able to present the insignia on behalf of his Government before the close of the meeting.

When the general business of the meeting was concluded, and after the completion of the number of 16 members, it became necessary to hold a meeting of the reconstituted committee in order to make appointments to the presidency and vice presidency, which had become vacant by the retirement of Sir Napier Shaw and M. Angot. By a unanimous vote of the committee Sir Napier Shaw was invited, and consented, to act as

president until the conference in 1923. Prof. E. van Everdingen was elected vice president, and Dr. Hesselberg, Director of the Meteorological Institute, Christiania, secretary.

It was agreed, on the invitation of Prof. E. van Everdingen, that a conference of directors of meteorological institutes and observatories should be held in Utrecht in 1923, either in the spring or autumn, as may be found the more convenient.

AMERICAN MEMBERS OF INTERNATIONAL COMMISSIONS.

The following names are those of American meteorologists who are members of the various commissions of the International Meteorological Committee:

Prof. C. F. Marvin, Chief of the U. S. Weather Bureau, Washington: International Commission for Meteorological Telegraphy; International Commission for Marine Meteorology; Commission du Réseau Mondial et de la Météorologie Polaire; International Commission for the Investigation of the Upper Air.

Dr. H. H. Kimball, Weather Bureau, Washington: International Commission for Solar Radiation.

Prof. J. Warren Smith, Weather Bureau, Washington: International Commission for Agricultural Meteorology.

Maj. W. R. Blair, Signal Corps, Washington: International Commission for the Application of Meteorology to Aerial Navigation.

Dr. C. G. Abbot, Smithsonian Institution, Washington: International Commission for Solar Radiation.

Dr. L. A. Bauer, Carnegie Institution, Washington: International Commission for Terrestrial Magnetism and Atmospheric Electricity.

RELATION OF COASTAL CURRENTS AND WINDS ON THE PACIFIC COAST.[1]

By H. A. MARMER.

[Abstract reprinted from *Jour. Washington Acad. of Sciences*, Oct. 4, 1921, pp. 397-398.]

This paper presented the results of an investigation of the speeds and directions of the current along the Pacific coast of the United States brought about by local winds. The investigation was undertaken primarily for the purpose of aiding the mariner and was based on observations made under the direction of the Coast and Geodetic Survey by members of the crews of the five light vessels stationed along the coast from San Francisco Bay to the Strait of Juan de Fuca. The apparatus used for measuring the speed and direction of the current was necessarily the simplest, and consisted of a 15-foot current pole, a log line graduated to knots and tenths for a run of one minute, a stop watch, and a pelorus. The wind velocity was estimated in accordance with the Beaufort scale.

Since the current as observed is the resultant of a number of different currents due to various causes, such as tides, winds, river discharge, and differences in density, the observations are tabulated with reference to various arguments. Thus by tabulating with reference to time of tide at a near-by port for periods of 29 days, the tidal current is derived. This current on the Pacific coast, offshore, is of the rotary type, the direction of rotation being clockwise, and shows considerable diurnal inequality. The wind current is derived by tabulating the observations with reference to winds of particular velocity and direction; then by summing for each such wind a large number of observations, the tidal current may be considered as very nearly eliminated.

In the present investigation the observations were tabulated with reference to winds from a given direction divided in groups covering a range of wind velocity of 10 miles. The results derived show that on the Pacific coast, at a distance of from 4 to 10 miles from the land, winds from 10 to 70 miles per hour will give rise to currents from one-fourth of a knot to over a knot; and this current will set, not in a direction of the wind, but in a direction of about 20° to the right of the wind. This has an important bearing on navigation, since winds blowing parallel to the coast or even away from the coast may give rise to currents tending to set a vessel on shore.

In the results presented for each of the light vessels the effect of fresh-water run-off at the light vessels stationed off San Francisco, Columbia River and Swiftsure Bank was sufficiently large in some cases to change the direction of the current brought about by winds of moderate velocity from the characteristic deviation of 20° to the right of the wind direction. But with increasing wind velocity the direction of the current approximated toward the direction of 20° to the right of the wind.

[1] Presented before Philosophical Society of Washington, May 21, 1921.

RESISTANCE OF AIR TO THE MOVEMENT OF SPHERES AND THE ASCENSIONAL RATE OF PILOT BALLOONS.

By C. E. BRAZIER.

[Abstracted from *Comptes Rendus* Oct. 17, 1921, pp. 644–646.]

Formulæ for the computation of the ascensional rate of pilot balloons are of the general form $V=m[A/(A+B)^{2/3}]^n$ in which A and B are the ascensional force and weight of the balloon respectively. But ascensional rates computed from formulæ based upon various determinations of m and n differ widely from one another. In order to determine some criterion for the correct values of these constants, the author has compared data obtained from ascents made by Rouch, Porte, Cave, and Dines, with certain aerodynamical studies made by Eiffel and Maurain upon spheres in moving air as observed in the wind tunnel.

In the equation $R=\dfrac{K\rho\pi D^2V^2}{4\rho(15°\text{C.},760\text{mm.})}$, in which R is the resistance of the sphere, K the coefficient of resistance, ρ the specific weight of the air, D the diameter of the sphere, and V the speed of the air current, the value of K varies according to the Reynold's number which is defined as $N=VD\rho/\eta$ (η being the viscosity of the air). Between the limits $N=100\times10^3$ and 300×10^3, K is in a large measure a function of the turbulence in the current of air.

It was desirable to compute the values of N and K from two and three theodolite balloon ascents and see if the laboratory relations between the two terms hold in the free air as well as in the wind tunnel. This study involved five assumptions: (1) That the balloon was spherical; (2) that the specific weight of hydrogen is 0.1 kg. per liter; (3) that one may neglect (*a*) the influence of water vapor on the specific weight of air, (*b*) the volume of the balloon envelope, (*c*) the pressure due to the tension of the balloon, (*d*) the difference in temperature between the gas in the balloon and the ambient air, and (*e*) the loss of ascensional force due to diffusion through the rubber; (4) that the mean ascensional speed is reached

at 5,000 meters elevation; and (5) that, at this level, the temperature and pressure are equal to their mean annual values, namely 260°A., and 406 mm.

It was found that the values of K do vary with N substantially as found in the laboratory. This permits of quantitative and qualitative work on the question in the wind tunnel and laboratory.—*C. L. M.*

ON THE COMPARABILITY OF ANEMOMETERS.

By C. E. BRAZIER.

[Abstracted and excerpted from *Comptes Rendus*, Paris Acad., Apr. 4, 1921, p. 843.]

Considerable differences in measured wind speed are observed if two anemometers of different types are exposed in a natural wind, and observations made repeatedly. The clue to the discrepancy lies in number of turns made by the two instruments in the same lapse of time. Inclined currents of air were used, and a comparison of the recorded horizontal component with the actual horizontal component was made. Comparing many types of anemometers in this manner, the following conclusions were drawn:[1]

1. The various types of anemometers, when perfectly calibrated in the laboratory, do not furnish indications comparable among themselves, when exposed in the complex movement of the natural wind, unless the inclination of the wind to the anemometer axis is less than 10°.

2. In an installation where there are frequent eddies due to pronounced vertical components of air movement:

(*a*) The indications of anemometers of the Richard type are too low, while those from the other instruments are too high.

(*b*) The excess of the values obtained with the Robinson anemometers is all the more accentuated when the difference between the diameters of the cups and the distance from center to center of opposite cups is least.

(*c*) The instruments whose indications approach most nearly the true velocities are the Richard type of anemometers and the Robinson with short arms (ratio of diameter of cups to that of cup-center distance 5 to 8).

(*d*) Until the inclinations are of the order of $\pm 50°$, measurements of the horizontal component by anemometers B and H agree to within nearly 5 per cent, as shown by the averages of the figures furnished.

(*e*) If the installation permits of the use of only a single instrument it is of advantage to employ a Richard anemometer or in its absence a Robinson anemometer of type H.

(*f*) Conclusions based upon comparisons in the natural wind, of anemometers, one of which has been tested in the laboratory, can be depended upon only when the conditions are the same as those under which the comparisons are made.

ON LONG-RANGE FORECASTING.[2]

By JEAN MASCART.

[Abstracted from *Comptes Rendus*, Aug. 22, 1921, pp. 419-420.]

Scientific attempts at long-range forecasting have been somewhat discredited by the necessary exposing of the unscientific methods of the almanac makers. But certain worth-while results have been achieved upon the basis of the assumption that similar weather will be followed by similar weather.

Upon such considerations, the author has made forecasts based upon weather of past years similar to the current weather (the details of the study are not presented), and has issued on the 20th of the month a forecast of the characteristics of the following month. In ordinary day-to-day forecasting his percentage of accuracy is 78.3, and in long-range forecasting, covering a period 10 to 41 days in advance, his percentage is 65.7.

That this is not due to chance is indicated by the fact that some months appear to be consistently better for this type of forecasting. The percentage is 76 in September, as opposed to 59.7 in March. The results are regarded as sufficiently good to warrant further systematic study.—*C. L. M.*

DISCUSSION.

It is to be hoped that M. Mascart, at some future time, will present the details of his method, which we infer to be one based upon ideas prevalent some 20 years ago, to the effect that like follows like in weather sequences.

This thought was frequently discussed by the forecasters of the Weather Bureau at the time and a number of suggestions looking to its practical application in the day-to-day forecasts were put forth.[3]

As may be readily inferred, the plan was to classify the daily weather maps in easily recognizable types and to refer each daily weather map as it was completed to its prototype. The attempt to classify the maps brought out the fact, already suspected, that many maps would defy classification and that still others, while they might resemble the general type in the larger features, yet on closer examination would be found to differ in some essential feature which would place it outside of the original classification.

On the whole the plan was not successful, although it possessed some decided advantages for purely local forecasting.

From the attempt to forecast day-to-day changes it is not a very long step to monthly and seasonal forecasting, and that, in part at least, is what M. Mascart has done.

The present writer has given some attention in a preliminary way to the sequence of weather from month to month. His experience in the study for the continental interior and the northeastern part of the United States leads to the belief that forecasts of a single element, say temperature or precipitation, for a month in advance would not be accurate in 50 per cent of the cases. Some modification of this statement could be made depending upon the closeness of approach to actual conditions that might be attempted. The value of any forecast is directly proportional to its accuracy and definiteness. It is of little moment to forecast that a coming month or season will be warmer or colder than the average. The forecast to be useful should specify how much or how little the departure will be, and in the case of a month whether the departure from the average will occur in the beginning, the middle, or the end of the month.—*A. J. Henry.*

[1] Excerpted from a translation by R. N. Covert.

[2] *Sur la prévision du temps à long terme.*

[3] See Brandenburg, F. H.; Brown, W. C.; Garriott, E. B. MO. WEATHER REV. 29 546-8. *Also* Richardson, H. W. *ibid* 31:68.

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING OCTOBER, 1921.

By HERBERT H. KIMBALL, Meteorologist.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48:225.

From Table 1 it is seen that direct solar radiation intensities were generally above normal October values at all the stations except Lincoln, Nebr. At Santa Fe, N. Mex., an intensity of 1.59 gram-calories per minute per square centimeter of normal surface, measured shortly after noon of the 18th, is the highest intensity ever measured at that station in October; and an intensity of 1.44 gram-calories, measured at Madison, Wis., just before noon of the 4th, is within 1 per cent of the maximum October intensity for that station.

Table 2 shows that the total solar and sky radiation received on a horizontal surface was generally above normal at both Washington and Madison, the excess at Washington averaging about 20 per cent of the normal. This excess is attributable principally to the unusual number of days in October with clear skies.

Skylight polarization measurements made on 14 days at Washington give a mean of 63 per cent, with a maximum of 72 per cent on the 14th. At Madison measurements made on nine days give a mean of 68 per cent, and a maximum of 74 per cent on the 4th. These are above the average values for October at both Washington and Madison.

TABLE 1.—*Solar radiation intensities during October, 1921.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance. 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Oct. 1	7.29	.....	0.91	1.06	1.22	1.41	1.22	.....	.....	.....	5.70
4	6.76	.....	.....	.....	1.27	.....	1.11	.....	.....	.....	4.57
5	5.79	0.84	0.94	1.07	1.17	1.39	1.17	0.92	0.82	0.73	5.16
6	7.29	0.84	0.94	1.08	1.23	1.43	1.22	.....	.....	.....	4.95
7	7.57	0.66	0.74	0.89	1.09	1.33	.....	.....	.....	.....	8.48
11	8.81	0.55	0.67	0.82	0.99	1.17	0.84	0.70	.....	.....	9.47
12	5.38	.....	0.86	1.03	1.23	1.47	1.28	0.97	.....	.....	3.30
13	4.37	0.75	0.83	1.02	1.22	1.46	1.10	0.92	0.79	0.67	3.45
14	5.79	.....	0.99	1.11	1.28	1.46	1.26	1.10	0.88	0.77	3.63
17	7.87	0.59	0.69	0.83	0.95	1.10	.....	.....	.....	.....	9.47
19	9.14	.....	.....	0.94	.....	.....	.....	.....	.....	.....	8.48
20	7.87	.....	.....	.....	1.21	1.33	.....	.....	.....	.....	4.95
21	4.37	.....	0.89	1.02	1.18	1.37	1.20	1.02	0.90	0.79	3.45
22	5.16	.....	1.06	1.16	1.32	1.49	1.29	1.09	0.96	0.86	3.99
24	7.87	.....	.....	.....	0.68	.....	0.89	0.60	.....	.....	7.87
26	4.17	.....	.....	.....	1.21	.....	1.21	1.04	0.89	.....	3.81
27	5.56	.....	.....	1.00	1.14	1.26	1.03	0.76	0.64	.....	6.02
29	7.57	.....	.....	0.79	.....	.....	.....	.....	.....	.....	7.57
Means	.....	0.70	0.87	0.99	1.15	1.36	1.14	0.91	0.84	0.76	.....
Departures	.....	−0.04	+0.04	+0.08	+0.05	.....	+0.05	+0.02	+0.09	+0.16	.....

* Extrapolated.

TABLE 1.—*Solar radiation intensities during October, 1921*—Contd.

Madison, Wis.

Date.	Sun's zenith distance. 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Oct. 1	6.27	.....	.....	1.03	.....	.....	.....	.....	.....	.....	7.57
3	6.02	.....	1.05	1.16	1.31	1.48	.....	.....	.....	.....	5.16
4	4.95	.....	1.08	1.20	1.34	1.54	1.31	1.17	.....	.....	4.57
5	5.16	.....	0.90	1.06	1.22	1.43	.....	.....	.....	.....	6.50
6	5.16	.....	0.93	1.06	1.22	1.39	.....	.....	.....	.....	5.36
8	3.81	.....	1.01	.....	.....	.....	.....	.....	.....	.....	4.17
12	4.37	.....	1.02	1.14	1.31	1.50	.....	.....	.....	.....	4.57
13	4.75	0.85	0.97	1.06	1.24	1.48	1.26	1.08	.....	.....	5.16
14	5.16	.....	.....	0.92	1.11	1.32	1.08	0.89	.....	.....	6.02
18	8.48	.....	.....	.....	1.16	.....	.....	.....	.....	.....	9.83
19	6.02	0.42	.....	0.66	.....	.....	.....	.....	.....	.....	5.79
21	5.36	.....	.....	1.13	1.28	.....	1.23	1.02	.....	.....	6.27
22	5.16	0.57	.....	.....	1.23	.....	.....	.....	.....	.....	6.02
Means	.....	0.71	0.99	1.04	1.24	1.45	1.22	1.04	.....	.....	.....
Departures	.....	+0.01	+0.08	−0.01	+0.07	.....	+0.05	+0.03	.....	.....	.....

Lincoln, Nebr.

Oct. 4	5.16	.....	.....	1.11	1.34	.....	1.27	1.10	0.96	0.85	7.87
10	5.79	.....	.....	.....	1.17	.....	.....	.....	.....	.....	18.59
12	3.81	.....	.....	.....	1.27	1.45	1.26	1.10	0.96	0.79	5.36
13	2.26	.....	0.96	1.08	1.17	.....	1.06	.....	0.67	0.54	6.02
17	8.81	.....	.....	.....	.....	.....	1.14	1.10	0.98	0.87	8.81
20	4.57	.....	1.02	1.15	1.22	.....	.....	.....	0.99	0.86	5.36
21	4.95	0.89	0.97	1.19	1.30	.....	.....	.....	.....	.....	6.02
22	4.37	.....	0.79	0.99	1.20	.....	.....	.....	0.85	0.71	5.36
27	6.27	.....	.....	1.21	.....	.....	1.32	1.15	0.99	0.89	5.36
31	6.76	.....	0.76	0.85	1.15	.....	1.20	1.00	0.79	0.66	8.48
Means	.....	(0.89)	0.90	1.08	1.23	(1.45)	1.21	1.09	0.90	0.78	.....
Departures	.....	−0.01	−0.07	−0.04	−0.05	.....	+0.03	+0.01	−0.04	−0.05	.....

Santa Fe, N. Mex.

Oct. 3	4.95	.....	.....	.....	.....	1.55	.....	.....	.....	.....	6.50
4	5.79	.....	1.14	1.22	.....	1.60	.....	.....	.....	.....	5.56
5	4.57	1.06	1.14	1.25	1.41	1.58	1.40	.....	.....	.....	4.95
18	3.45	.....	.....	.....	.....	.....	1.40	1.28	1.16	.....	2.62
19	3.00	1.16	1.22	1.30	.....	1.63	.....	.....	.....	.....	3.15
20	3.99	.....	.....	.....	.....	.....	1.43	1.18	1.06	.....	4.17
21	3.63	.....	.....	.....	.....	.....	1.45	1.24	1.14	.....	3.63
26	3.99	1.11	1.25	1.33	1.49	1.68	1.46	1.28	.....	.....	4.37
27	3.15	1.11	1.22	1.26	.....	.....	.....	.....	.....	.....	3.00
Means	.....	1.11	1.19	1.27	1.45	1.61	1.43	1.24	1.12	.....	.....
Departures	.....	+0.02	+0.03	+0.03	+0.07	.....	+0.03	±0.00	+0.01	.....	.....

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation. Washington.	Madison.	Lincoln.	Average daily departure for the week. Washington.	Madison.	Lincoln.	Excess or deficiency since first of year. Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 1	367	329	.....	+40	+48	.....	+1,973	−3,041	.....
8	378	272	.....	+71	+20	.....	+2,473	−2,899	.....
15	335	213	.....	+48	−12	.....	+2,806	−2,985	.....
22	348	206	.....	+80	+ 1	.....	+3,366	−2,978	.....

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE, AUGUST AND SEPTEMBER, 1921.

NOTE.—The above reports will be published in a later issue of the REVIEW, not having been received in time for insertion here.—EDITOR.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The weather over the North Atlantic during the month of October, taken as a whole, was most unusual. The average pressure for the month was considerably below the normal at land stations on the coast of Newfoundland and in the Azores; it was above in the British Isles and not far from normal on the American coast and at the Bermudas.

The number of days with winds of gale force was very much greater than usual over the western portion of the steamer lanes, and also in the Caribbean Sea and West Indies, as well as in the region between the Bermudas and the coast of Florida.

On October 1 and 2 there was a well developed LOW central near latitude 48° N., longitude 30° W. On the 1st moderate northerly and northwesterly gales prevailed in the western quadrants, while on the 2d the storm area extended as far south as the Azores. Storm logs follow:

British S. S. *Vasconia:*

Gale began on the 1st, wind NW. Lowest barometer 29.41 inches at 3 p. m. on the 1st, wind NW.; position, latitude 47° 10′ N., longitude 36° 42′ W. End of gale on the 2d. Highest force of wind 10; shifts NW.–N.

Dutch S. S. *Van Rensselaer:*

Gale began on the 2d, wind W. Lowest barometer 29.43 inches at 8 a. m. on the 2d, wind NW.; position, latitude 39° 34′ N., longitude 30° 45′ W. End of gale on the 2d, wind NNW. Highest force of wind 9, NW.; shifts WNW.–NW.

From the 2d to the 5th there were no well-defined LOWS, although a number of reports were received from vessels, in widely scattered positions, that encountered moderate gales during that period. On the 6th the first of the severe disturbances of the month in this locality, appeared off the coast of Newfoundland. In the morning the barometer at St. Johns read 28.96 inches and violent gales were reported by a number of vessels between the 40th and 52d parallels and the 40th and 60th meridians. This LOW moved rapidly toward the northeast and on the 8th the center was apparently not far from Iceland, although it was impossible to determine its position accurately on account of lack of observations. Storm logs follow:

British S. S. *Manchester Merchant:*

Gale began on the 6th, wind W. Lowest barometer 29.05 inches at 6.30 a. m. on the 6th, wind W., 11; position, latitude 47° 28′ N., longitude 50° 43′ W. End of gale on the 7th, wind WSW. Highest force of wind 11, W.; steady from W.

American S. S. *Dirigo:*

Gale began on the 7th; position, latitude 54° 47′ N., longitude 29° 50′ W. At 4 a. m. on the 7th, wind WNW., 7; barometer 29.38 inches. At 8 a. m., WSW., 8; 29.49 inches. At 4 p. m., WSW., 9; 29.54 inches. At 8 p. m., W., 9; 29.62 inches. End on the 9th, wind N.; position, latitude 51° 22′ N., longitude 37° 20′ W.

American S. S. *Ipswich:*

Gale began on the 6th, wind S. Lowest barometer 28.98 inches at 4 p. m. on the 6th, wind SW., 11; position, latitude 50° 35′ N., longitude 44° 34′ W. End of gale on the 7th, wind SW. Highest force 11, SW.; steady from SW.

On the 9th there was a disturbance central near the west coast of Newfoundland, and southerly gales prevailed over a limited area between the 40th and 45th parallels. On the same day northerly gales accompanied by high barometric readings were encountered by vessels in the vicinity of the Azores, and the land station at Horta reported, wind N., force 8; barometer 30.22 inches. Storm log:

American S. S. *New Britain:*

Gale began on the 8th, wind, SSE. Lowest barometer 29.80 inches at 8 a. m. on the 8t , wind S, 6; position, latitude 41° 30′ N., longitude 58° 12′ W. End of gale on the 9th, wind S. Highest force 9, S.; shifts SSE.–S. by W.

From the 14th to the 16th a disturbance of limited extent moved slowly along the coast from the south of Florida to Hatteras. It then curved eastward, increasing in extent and velocity, and on the 21st the center was a short distance northwest of the Azores. Storm logs follow:

American S. S. *F. D. Asche:*

Gale began on the 13th, wind NE. Lowest barometer 29.80 inches at 4 p. m. on the 16th, wind NE., 9; position, latitude 34° 29′ N., longitude 75° 03′ W. End on the 17th, wind NE. Highest force 9, NE.; steady from NE. Heavy rain squalls with rough and confused sea.

American S. S. *Colorado Springs:*

Gale began on the 17th, wind SE. Lowest barometer 29.17 inches at 6 a. m. on the 18th, wind SW., 8; position, latitude 39° 06′ N., longitude 58° 51′ W. End of gale on the 18th, wind NNW. Highest force 9; shifts SE.–W.–NNW.

American S. S. *Chickasaw:*

Gale began on the 19th, wind NE. Lowest barometer 29.24 inches at 6 a. m. on the 19th, wind NE., 10; position, latitude 40° 30′ N., longitude 48° 26′ W. End at midnight on the 19th, wind NE. Highest force 11, NE.; shifts not given.

American S. S. *Saguache:*

Gale began on the 19th, wind SE. Lowest barometer 29.26 inches at 3 a. m. on the 21st, wind SE.; position, latitude 41° 35′ N., longitude 31° 40′ W. End of gale on the 22d, wind NNE. Highest force 12; shifts SSE.–NNE.

On the 22d the region between the 40th and 52d parallels and the 40th and 55th meridians was covered by strong southerly to westerly gales, due to a depression apparently centered over Labrador. This disturbance must have moved rapidly northward during the next 24 hours, as it had disappeared by the 23d. Storm logs follow:

British S. S. *Barbadian:*

G. M. N. position on the 22d, latitude 42° 48′ N., longitude 52° 18′ W. A squall of gale force from SW., lasting from 8 to 10 a. m.

Swedish S. S. *Carlsolm:*

Gale began on the 22d, wind SE. Lowest barometer 29.24 inches at 10 p. m. on the 22d, wind S., 7; position, latitude 50° 50′ N., longitude 45° 13′ W. End on the 24th, wind WSW. Highest force 10; shifts S.–WSW.

The tropical hurricane from the 22d to the 29th is fully described elsewhere (see pp. 567–570). Charts IX to XIV cover the period from the 24th to the 29th, inclusive, and it can be seen from a glance at them that this disturbance was most unusual in many respects, especially for so late in the season. Storm logs follow:

Japanese S. S. *Yuri Maru:*

Gale began on the 22d, wind E. Lowest barometer 29.44 inches at 9 p. m. on the 22d, wind E.; position, latitude 19° 39′ N., longitude 84° 20′ W. End on the 23d, wind SSW. Highest force 10, shifts not given.

American S. S. *El Estero:*

6 p. m. 24th, position, latitude 25° 36′ N., longitude 84° 24′ W.; barometer 29.11 inches; wind E., 12; rain. 10 p. m. lowest reading, 27.84 inches. Wind calm for 30 minutes, then started again veering to SE. 3 a. m., 25th, wind SW. and moderating. From 8 p. m. to 10 p. m. on the 24th wind about 110 miles an hour with heavy rain.

The barometer on board the *El Estero* has been recently compared, and is apparently reliable, so the most unusual reading of 27.84 inches (corrected) is probably very nearly correct.

American S. S. *El Valle:*

10 a. m., 24th; position, latitude 26° N., longitude 86° 18′ W.; barometer 29.69 inches; wind E., 9; rain. 7 p. m., 24th; position, latitude 25° 36′ N., longitude 85° 30′; barometer 29.32 inches (lowest); wind N., 10; overcast. Wind shifted to fresh NE. gale at noon, then gradually to NNE. and N., whole gale. At 8 p. m. gradually decreased.

Danzig S. S. *Baltic:*

Gale began on the 24th, wind E. Lowest barometer 28.33 inches at 3 a. m. on the 24th, wind E., 12; position, latitude 24° N., longitude 85° 10′ W. End on the 25th, wind S. Highest force 12, E.; shifts not given.

American S. S. *Westland:*

Gale began on the 23d, wind SE. Lowest barometer 29.48 inches at 11 p. m., on the 23d, wind SE., 11; position, latitude 25° N., longitude 81° 40′ W. End on the 25th, wind N. Highest force 11; shifts SE.–E.–ENE.–NNE.–N.

American S. S. *El Sol:*

Twenty-fifth, overcast sky with heavy rain squalls and fresh east winds to strong east, south, and SSW. gales with heavy sea. Lowest barometer 29.52 inches at 3 p. m. At 5 p. m barometer began to rise, and wind moderate. Midnight strong SW. winds; barometer 29.72 inches. Position at 7 p. m. on the 25th, latitude 25° 30′ N., longitude 80° 02′ W.; barometer 29.60 inches; wind S. by W., 8; rain.

American S. S. *F. D. Asche:*

Gale began on the 25th, wind ESE. Lowest barometer 29.27 inches at 2 p. m. on the 26th, wind SW.; position, latitude 27° 30′ N., longitude 78° 30′ W. End on the 27th, wind WNW. Highest force of wind 12, SE.; shifts SW.–SW. by W. Oct. 26, frequent passing ugly and very dark low clouds with heavy rain and violent wind. Also several waterspouts.

American S. S. *Acme:*

Gale began on the 25th. Lowest barometer 29.60 inches at 2 p. m. on the 25th; position, latitude 30° 35′ N., longitude 79° 12′ W. End on the 27th, wind E. Highest force 10, E.; shifts E.–NE.

American S. S. *General W. C. Gorgas:*

On the 26th at 7 p. m.; position, latitude, 29° 48′ N., longitude 73° 52′ W.; barometer 29.60 inches; wind E., 8; rain. On the 27th, 7 p. m., position, latitude 30° 06′ N., longitude 73° W.; barometer 29.75 inches; wind, NE., 10; rain.

British S. S. *Magellan:*

Gale began on the 26th, wind, S. Lowest barometer 29.26 inches at 2 p. m., on the 27th, wind, SW., 11; position, latitude 27° 45′ N., longitude 73° 11′ W. End on the 28th. Highest force of wind 11, SW.; shifts, SW.–WSW.–W.–WNW.

American S. S. *Aryan:*

Gale began on the 27th, wind, SE. Lowest barometer 28.96 inches at 1 p. m., on the 27th, wind, ESE., 9; position, latitude 28° 20′ N., longitude, 70° 30′ W. End on the 28th, wind, ENE. Highest force 12; shifts, ESE.–E.–ENE.–NE.

American S. S. *Saguache:*

Gale began on the 28th, wind E. Lowest barometer 29.56 inches, wind E., 9; position, latitude 27° 14′ N., longitude 64′ W. End of gale on the 29th, wind N. Highest force 11; shifts E.–ENE.

On the 26th there was a LOW central about 150 miles east of St. Johns, Newfoundland, that remained nearly stationary during the remainder of the month. It reached its greatest intensity on the 29th, and on that date the center was near St. Johns, where a barometer reading of 28.94 inches was recorded. According to press reports this was the most severe storm experienced in the vicinity of Newfoundland in over 60 years, 13 vessels being wrecked, while there were numerous other casualties on both land and sea. Charts XI to XVI show the conditions that existed from the 26th to the 31st, inclusive, and will give an idea of the intensity and extent of this disturbance. Storm logs follow:

Belgium S. S. *Kremlin:*

Gale began on the 26th, wind SSE. Lowest barometer 28.53 inches at 9 a. m. on the 26th, wind WNW.; position, latitude 47° 04′ N., longitude, 45° 05′ W. End on the 30th, wind WNW. Highest force 10; NW.–SW.

British S. S. *Mackinaw:*

Gale began on the 27th, wind NNE. Lowest barometer 28.91 inches at 2 p. m. on the 29th, wind NNE., 11; position, latitude 43° 45′ N., longitude 55° 02′ W. End on the 31st, wind NNE. Highest force 12; shifts N.–NW.–W.

British S. S. *Vasconia:*

Gale began on the 28th, wind W. Lowest barometer 28.64 inches on the 29th, wind NNW., 11; position, latitude 43° 33′ N., longitude 52° 38′ W. End on the 31st. Highest force 11; shifts NW.–WNW.–N.

British S. S. *Turcoman:*

Gale began on the 28th, wind NNE. Lowest barometer 29.60 inches on the 29th, wind NNE.; position, latitude 52° N., longitude 54° 30′ W. End on the 30th, wind NNE. Highest force 11; steady from NNE.

Belgium S. S. *Gothland:*

Gale began on the 31st, wind N. Lowest barometer 29.12 inches at 10 a. m. on the 31st; position, latitude 44° 25′ N. longitude 49° 50′ W. End on November 1, wind N. Highest force 9; shifts N.–NW.

From the 27th to the 31st a number of reports were received from vessels in the region between the Azores and the Bermudas that encountered winds of gale force, as shown by Charts XII to XVI, inclusive. Storm logs follow:

British S. S. *Nubian:*

Gale began on the 26th, wind SSW. Lowest barometer 29.56 inches at 3.45 a. m. on the 27th, wind NE.; position, latitude 32° 50′ N., longitude 52° 05′ W. End on the 28th, wind ENE. Highest force 8; shifts SSW.–WNW.–NE.

British S. S. *Kabinga:*

Gale began on the 28th, wind SSE. Lowest barometer 29.32 inches at midnight on the 30th, wind WSW., 10; position, latitude 36° 06′ N., longitude 39° 45′ W. End on November 1. Highest force 11; shifts W.–SW.–NW.

American S. S. *Edgefield:*

At 10 a. m. on the 31st, wind WNW., 8; barometer 29.53 inches. 1 p. m. wind W., 7; barometer 29.62 inches; position, latitude 37° 45′ N., longitude 33° 20′ W. 4 p. m. wind SSW., 6; barometer 29.66 inches. Shifts of wind very erratic, changing from one direction to another in a minute's time and blowing with equal force. Sea confused.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

October weather on the North Pacific Ocean was chiefly characterized by four disturbances of tropical origin[1] which moved northward one after another in different parts of the ocean. The first of these was the typhoon which appeared to the south of Guam Island on the 2d. This traveled in a northwesterly direction during the following three days and on the 6th and 7th recurved to the northeastward. On the 8th it was some 250 miles west of the Bonin Islands. Little is known regarding the intensity of this storm or of its history subsequent to the 8th.

The second disturbance formed near the Hawaiian Islands about the 5th, and during the next several days moved slowly northward toward the Gulf of Alaska, there merging with a depression which had advanced

[1] Late reports indicate that the last one of these storms may have been of extratropical origin. See article by Rev. José Coronas, S. J., on pp. 581–582.

eastward over the Aleutian Islands on the 7th. From the 8th to the 10th the combined depression was ill defined, but on the 11th it increased in energy and by the 12th covered the whole of the Gulf of Alaska, as well as near-by portions of the ocean. Between the 12th and 16th it remained nearly stationary as a fairly vigorous disturbance, causing moderate to fresh westerly gales along the eastern portion of the northern steamer lane. On the 17th it moved inland on the British Columbian coast and a fresh depression formed in the ocean to the northward of the Hawaiian Islands.

In connection with the latter depression an interesting development was reported by Capt. H. J. Satterly of the British S. S. *Adna*. At noon on the 17th the *Adna*, San Francisco for Kobe, was in latitude 36° 40′ N., longitude 147° 29′ W., barometer 29.32 inches, wind SSW. At 2:30 p. m. the barometer had fallen to 29.10 inches and the wind had backed to southerly, increasing to force 10–11. There was a very heavy, breaking southerly sea. At 3 p. m. the wind started to veer to westward, and at 4 p. m., according to Capt. Satterly, the disturbance suddenly blew out, the barometer standing at 29.04 inches. There was a very confused sea. After 4 p. m. the barometer rose quickly, and at 6:15 p. m. read 29.42 inches. After the passing of the disturbance the wind came down from the NW. in a heavy blast, later settling down to a moderate gale. Late on the previous day, states Capt. Satterly, the wind had twice in quick succession veered round the compass, and formations that looked like small whirlwinds were seen in various places traveling in a northeasterly direction. Capt. Satterly expressed the opinion, which subsequent developments appear to confirm, that these signs pointed to the formation of a small circular storm. The whole circumstance was not unlike the development on January 29, 1921, when a secondary depression formed near the coast of the United States and traveled northward, causing great destruction of valuable timber in the States of Oregon and Washington.[2]

The third disturbance appeared to the southwest of Midway Island on the 9th and by the evening of the 10th a moderate SW. gale was blowing at that place. The barometer read 29.62 inches, having fallen steadily since the evening of the 6th, when it stood at 30.18 inches. Capt. Geo. H. Piltz, of the American schooner *Flaurence Ward*, lying at Midway Island, reported that the barometer continued to fall until noon of the 11th, when it read 29.35 inches. At that hour a strong SSW. gale was blowing. By 4 p. m. of the 11th the wind had decreased to a moderate gale and the barometer was rising. This depression moved slowly east-northeastward without displaying much energy, and lost identity in the region south of Alaska.

The fourth and most important disturbance of the series had its origin still farther to the westward. The opinion that this storm was of tropical origin at first appeared to be confirmed by reports of a typhoon between Guam and the Bonin Islands from the 13th to 18th, but the presence of depressions to the north of Japan on the 16th–18th makes the case somewhat uncertain. The first vessel to become involved among those from which reports have been received was the American S. S. *West Nomentum*, Capt. R. N. Canghell, Observer H. A. Dunham, Portland for Yokohama. At midnight of the 19th–20th, when the *West Nomentum* was in latitude 37° 10′ N., longitude 160° E., the barometer fell to 28.84 inches. The wind at this time was S., force 10, the highest experienced by this vessel during the storm. The shifts of wind were SW., W., WNW.

The next reporting vessel to become involved was the British S. S. *Bessie Dollar*, Capt. J. Kerr, Observer M. Buchanan, Kobe for Vancouver. At 2 p. m. on the 20th, when in latitude 45° 12′ N., longitude 160° E., the barometer fell to 28.90 inches. The wind at that time was northerly, force 8, the *Bessie Dollar* being on the northern side of the storm. Shifts of wind were N., NW., WNW.; highest force 8, N.

The vessels perhaps most heavily involved in this storm were the Japanese S. S. *Kashima Maru*, the American S. S. *Steel Voyager*, and the British S. S. *Tyndareus* and *Empress of Asia*. The first-named vessel, under command of Capt. K. Itsuno, observer H. Tanaka, was proceeding from Yokohama toward Seattle. According to the storm log of the vessel the gale began on the 20th, wind E., force 7; the lowest barometer recorded was 27.78 inches (approximately) at 3 a. m. of the 21st, in latitude 48° 05′ N., longitude 171° E.; the highest force of wind was 12, SSW., which occurred at the time of lowest barometer. The storm ended for this vessel on the 22d, wind W., force 7.

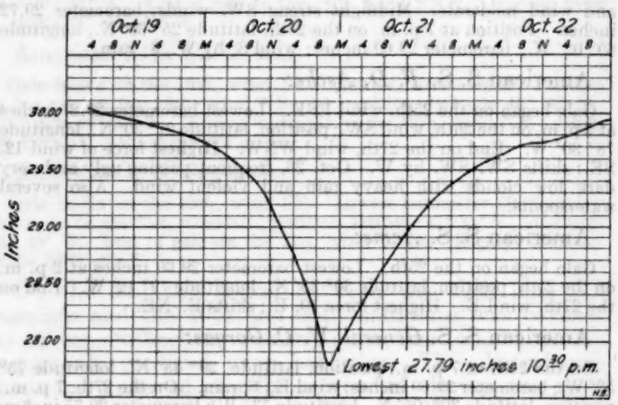

FIG. 1.—Fluctuation of barometer October 19-21, 1921, as observed on board the British S. S. *Tyndareus*.

Press reports sent out by radio from the *Kashima Maru* immediately after the storm quoted Capt. Itsuno to the effect that it was the worst in his 30 years' experience at sea. The waves were described as towering 60 feet above the bridge, thus having a height of 120 feet.

The *Steel Voyager*, bound from Kobe to Puget Sound ports, was nearest the storm center between 7 and 7:30 p. m. of the 20th, in latitude 43° N., longitude 172° E., at which time the barometer read 28.46 inches. Comparative readings made after the termination of the voyage indicate that a correction of −0.15 inch should be applied. According to Mr. Raymond Leslie, second officer, the vessel was swept continuously by heavy seas. The force and shifts of wind are not known, but a chart of the probable storm track shows that the center passed some distance to the westward of the *Steel Voyager*.

The *Tyndareus*, Capt. C. A. Wilson, observer W. O. Griffiths, bound from Yokohama to Victoria, was somewhat to the southwestward of the *Kashima Maru*. The lowest barometer observed on board the *Tyndareus* was 27.79 inches. This occurred at 10:30 p. m. on the 20th, in latitude 47° N., longitude 169° 18′ E. The fluctuations of the barometer on the *Tyndareus* are shown in figure 1, the curve being constructed from the readings contained in a very complete report of the storm made by

[2] See MO. WEATHER REV., January, 1921, 49, 31.

Mr. Griffiths. The readings employed in constructing the curve have not been corrected for instrumental error, which, according to comparisons made at the end of the voyage, is −0.15 inch.

The *Empress of Asia* was also heavily involved in the storm and recorded the lowest barometer in the group of four vessels named, 27.39 inches, corrected. This vessel, under command of Capt. L. D. Douglas, R. N. R., Observer J. F. Patrick, was bound from Vancouver to Yokohama. Her storm log is given herewith, as well as a reproduction of the barograph trace obtained, figure 2.

October 20. Noon position, latitude 49° 51′ N., longitude 174° 09′ E., barometer 29.81 inches, wind S., force 5, backing to ESE. at 1 p. m. and increasing in force. 4 p. m., barometer 29.29, temperature 48°, wind force 7, raining. 8 p. m., latitude 49° 05′ N., longitude 170° 34′ E., barometer 28.78, wind increasing to strong ESE. gale with high seas and continuous rain. 10 p. m., wind force 10, barometer 28.13, falling rapidly. Midnight, wind decreasing and backing to NE., barometer 27.53, temperature 50°.

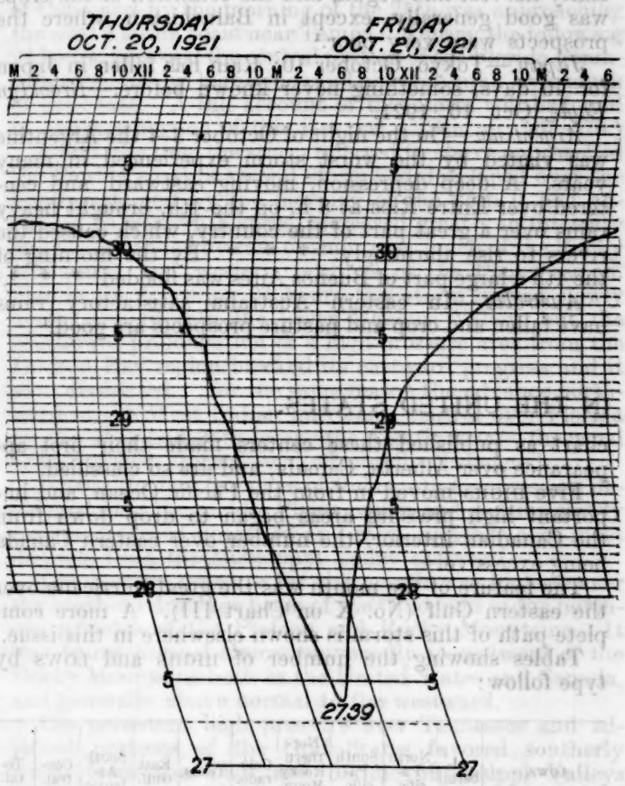

FIG. 2.—Barograph trace, October 20–21, 1921, British S. S. *Empress of Asia*.

October 21. 1 a. m., latitude 48° 33′ N., longitude 168° 03′ E., light variable winds with high SE. swell, barometer 27.48 (correction −.09 inch). 1:15 a. m., wind changed to NW., force 6, with high, confused sea. 2 a. m., barometer 27.50. 3 a. m., barometer 27.66, wind increasing to force 10, mountainous seas. Reduced speed, wind and sea brought 3 points on starboard bow. 4 a. m., latitude 48°14′ N., longitude 166° 33′ E., wind increasing to hurricane force with very high, confused sea, barometer 27.91. 5 to 7 a. m., terrific squalls and high drift, being unable to see more than a ship's length, seas phenomenal. 8 a. m., latitude 48° 12′ N., longitude 165° 52′ E., barometer 28.60, patches of blue sky appearing. 8 to 11 a. m., wind continuing to force 12 with heavy hail squalls. Noon, latitude 48° 08′ N., longitude 165° 15′ E., weather moderating slightly to force 7 at midnight. Position at midnight, latitude 46° 58′ N., longitude 162° 01′ E.

This storm possessed at a high latitude the pressure characteristics of a tropical cyclone, in this respect resembling the West Indian hurricane of September 7–18, 1921, in the North Atlantic Ocean. It continued its northeasterly movement to Bering Sea where, on the evening of the 21st, a barometer reading of 28.66 inches was recorded at St. Pauls, Pribilof Islands. On the following day it was central over the Alaskan Peninsula, very much diminished in energy.

Aside from the four storms mentioned no other disturbance of a general character prevailed during the month, so far as known. One of moderate extent and intensity, however, developed on the 9th off the southwest Mexican coast. It was experienced by the British S. S. *Mongolian Prince*, Capt. J. Halloway, Observer J. McLoughlin, Vancouver for Panama. The storm log of this vessel is as follows:

Gale began on the 9th, wind ESE.; heavy southerly swell; lowest barometer, 29.68 inches, occurred at 4 a. m., same date, in latitude 17° 15′ N., longitude 101° 51′ W.; gale ended on 10th; highest force of wind, 7, SE.; shifts ESE.–SE.

Pressure conditions at the island stations of Dutch Harbor, Honolulu, and Midway Island were not marked by any unusual fluctuations. For the month as a whole pressure was below normal by small amounts at all three stations.

NO TYPHOON IN THE PHILIPPINES DURING OCTOBER, 1921. ONLY THREE IN THE PACIFIC.

By JOSÉ CORONAS, S. J., Chief Meteorological Division.

[Weather Bureau, Manila, P. I., Nov. 4, 1921.]

There was not a single typhoon traversing the Philippines during last October; and even of the three typhoons that have been observed in the Pacific only one approached sufficiently near to influence slightly our weather in the archipelago. Hence the lack of rain reported generally from our stations, especially from those of the western and northern part of Luzon as can be seen in the following table:

Rainfall data for October, 1921.

Station.	Total.	Departure from normal.
	mm.	mm.
Surigao	231.3	− 16.4
Cebu	146.3	− 60.2
Iloilo	146.4	−114.0
Legaspi	259.7	− 68.8
Batangas	110.3	− 87.6
Manila	37.4	−151.0
San Isidro	122.7	− 56.4
Iba	104.9	− 68.6
Dagupan	97.0	− 89.8
Baguio	115.6	−271.5
San Fernando, La Union	2.0	−142.8
Vigan	2.5	−162.6
Tuguegarao	24.6	−227.5
Laoag	4.6	−215.9
Aparri	190.8	−107.1

The first Pacific typhoon was formed on 27th to 28th of September near longitude 130° E. and latitude 10° N.; it moved practically to the north until the 30th when it recurved northeastward, probably filling up on the 2d or 3d of October near longitude 135° E. and latitude 20° N.

The second typhoon formed on October 1 to 2 over the western Carolines in about longitude 145° E. and latitude 8° N. It moved northwestward, passing about halfway between Guam and Yap on the 3d. On the 6th the typhoon began to recurve northeastward near longitude 135° E. and latitude 20° N. The weather maps of Tokyo show this typhoon moving north-northeast near the eastern coast of Japan on the 10th and 11th.

The S. S. *Creole State* was under the influence of this typhoon between the Ladrone Islands and Luzon on October 4 to 8.

The third typhoon appeared northeast of Guam on the 13th near longitude 150° E. and latitude 17° N. It moved probably west by north first, then west-northwest and recurved gradually to north and northeast to the south of the Bonins. The center was situated at noon of the 18th southeast of the Bonins in about longitude 145° or 146° E. and latitude 24° or 25° N., moving apparently east-northeast. The S. S. *Empress of Asia* was in the center of a big cyclone on October 21 in about longitude 168° 3′ E. and latitude 48° 33′ N.[3] It is not probable, however, that the disturbance met by this steamer was the typhoon just mentioned, but rather a continental depression which coming apparently from Manchuria traversed northern Japan on 18th to 19th and developed probably in a big cyclone in the Pacific east of northern Japan.

[3] See report on p. 581.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Alaska.—Dawson, October 23: Navigation on the Yukon River is closed for the winter * * *.—*Washington Evening Star*, Oct. 24, 1921.

British Isles.—The rainfall of the month was below the average generally in the southeastern half of the British Isles, the areas with more than the average lying mainly in the northwest of Ireland and west of Scotland. * * *

In London (Camden Square) the mean temperature was 56.2° F., or 6° F. above the average, and the highest for October in 64 years' record * * *.[1]

Belgium.—In Belgium the drought again became serious, and it was necessary to close factories and limit the consumption of water for domestic purposes.[1]

Switzerland.—Berne, October 21: There has been no rain worth mentioning throughout Switzerland since August, and the drought which began a year ago still continues. * * * Forest fires are again reported, something unprecedented at this season. * * * The Rhine has not been so low for a century, and navigation for boats with deep draft is impossible.—*New York Times*, Oct. 22, 1921.

India.—The month opened with a vigorous monsoon in the peninsula and rainfall above normal in most places. Early harvest had begun, and the condition of the crops was good generally, except in Baluchistan, where the prospects were very poor.[1]

Japan.—Tokyo, October 10: Rain has fallen in Japan for 40 days, something never known before.—*Brooklyn Eagle*, Oct. 10, 1921.

Argentina.—On the night of October 3–4 the Argentine was visited by the worst storm experienced in many years. A deep depression, moving eastward, and centered over Entre Rios at 8 h. on the 4th, brought heavy rains over a great part of the country, which caused the rivers to rise alarmingly. * * * By the morning of the 4th a large part of Buenos Aires was flooded * * *.[1]

Australia.—In eastern Australia satisfactory rains have fallen and crop and pasture prospects are good.[1]

[1] *Meteorological Magazine*, November, 1921, p. 306.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

One of the outstanding features of the weather of the month was the continued high temperature in practically all parts of the country and deficient precipitation except in Florida and the Lake region. The monthly mean pressure was below normal east of the Rocky Mountains as in the preceding month, and the number of cyclones and anticyclones was greater than the average for October.

The daily weather chart of the 25th shows the presence of three very deep depressions of the barometer, the first a tropical cyclone passing from west to east over the Florida Peninsula with central pressure (as afterwards developed) below 29 inches; the second over western Kansas, lowest pressure 29.26 inches and the third over southeastern Alaska, lowest pressure 29.02 inches. Such extreme variations in pressure are unusual in October.

CYCLONES AND ANTICYCLONES.

By W. P. DAY, Observer.

Alberta LOWS were again in excess. The centers of several disturbances of North Pacific origin passed inland between Sitka, Alaska, and Vancouver Island, British Columbia, causing southerly gales on the Washington and Oregon coasts; however, on the weather chart as published these centers made their first appearance over Alberta, Canada, and are so classified.

Five HIGHS moved in from the Pacific Ocean, and important high pressure areas began to drop down from the Canadian interior, the number over eastern Canada being excessive.

The feature of the month was the great hurricane over the eastern Gulf (No. X on Chart III). A more complete path of this storm is shown elsewhere in this issue.

Tables showing the number of HIGHS and LOWS by type follow:

LOWS.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
October, 1921	7.0	.....	1.0	1.0	2.0	.....	1.0	2.0	2.0	16.0
Average number, 1892–1912, inclusive	4.2	1.3	0.7	0.5	1.7	0.7	0.4	0.5	0.3	10.3

HIGHS.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
October, 1921	4.0	1.0	3.0	.....	3.0	11.0
Average number, 1892–1912, inclusive	2.8	0.9	3.0	1.2	0.6	8.5

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

PRESSURE AND WINDS.

The greater part of October, 1921, was notably free from violent atmospheric disturbances, and on the whole the reputation of the month as one of the best of the year was fully maintained. Moderately high pressure with fair and mild weather continued almost unbroken during the first three weeks over nearly all central and southern districts.

No storms of importance occurred during this period and precipitation after the first few days was usually confined to small areas along the northern border, and in portions of the upper Mississippi Valley, Great Lake region, and thence eastward. About the 23d a storm of the West Indian hurricane type crossed the western end of Cuba and by the morning of the 25th was approaching the west Florida coast near Tampa. During the following 24 hours it crossed the central portion of the Florida Peninsula attended by high winds and heavy rainfall over much of the State. A full account of this storm will be found in another portion of this REVIEW. (See pp. 567-570.)

About the time the storm referred to above approached the Florida coast, a second storm had developed over the Southwest, and by the morning of the 25th it had advanced to western Kansas, increased greatly in intensity and was attended by rain or snow over much of the Rocky Mountains and western portions of the Plains region. During the following 24 hours this storm moved slowly northeastward into the lower Missouri Valley, but the southward prolongation of a high-pressure area from the Hudson Bay region blocked its eastward progress and it soon dissipated. For the same reason the advance northward of the West Indian hurricane, central over Florida on the 25th and 26th, along the Alantic coast—the usual course of such storms—was effectually obstructed.

During the last few days of the month low pressure developed over the middle Plains region and drifting slowly eastward caused unsettled and rainy weather over most districts from the Mississippi Valley eastward.

The average pressure for the month was highest over the southern drainage basin of the Ohio, and in the northern portions of the Plateau and Rocky Mountains. It was below normal almost universally to eastward of the Rocky Mountains both in the United States and Canada, and generally above normal to the westward.

The persistent high pressure over Tennessee and adjacent portions of the Gulf States favored southerly winds from the Ohio and middle Mississippi Valleys northward to near the Canadian boundary, while much of the region to the southward and eastward of the high area had northerly or northeasterly winds. Northwesterly winds prevailed generally along the northern border from the upper Lakes to the Rocky Mountains. West of the Rocky Mountains the winds as usual were greatly diversified.

High winds were of infrequent occurrence and usually affected but small areas, save during the passage of the West Indian hurricane over the Florida Peninsula, where they covered an extensive area and caused much damage.

TEMPERATURE.

Marked variations to colder or warmer were infrequent during the month and changes of as much as 20° in 24 hours were observed in but few instances, these being confined mainly to the early portion of the month.

The first decade was moderately cool over the districts from the Great Plains eastward, and this condition persisted over the southeastern districts till after the middle of the month. This was mainly due to the clear weather, particularly at night, whereby radiation became unduly active, causing lower night temperatures than usually prevail, the days being generally warm.

Over the more western districts the month was al wholly warmer than the average, particularly in central and northern portions of the Rocky Mountain and Plateau regions, where temperatures below normal were confined mainly to three or four days only.

The latter half of the month was warmer than usual in nearly all portions, the week ending October 25 being particularly warm in the Rocky Mountain and Plateau regions, and the last week shows nearly as much excess in the great central valleys.

The warmest and coolest periods for the different sections were widely scattered through the month. The principal warmest periods were about the 2d and 3d over the southeastern districts, the 19th and 20th over California and the far Southwest, and the 24th and 25th in the Ohio Valley and adjacent territory. The lowest temperatures were observed about the 8th to 12th in the central valleys, near the middle of the month in the East Gulf and South Atlantic States, and near the middle of the last decade in the western mountain districts.

For the month as a whole the average temperature was above normal over nearly the entire country, only a small area of the southern Appalachian Mountain region and portions of the East Gulf and South Atlantic States having averages below normal.

In portions of the Rocky Mountain and Plateau regions the month was the warmest October during 50 years of observation, and over the north-central districts it added another to the already abnormally long list of months with average temperatures above the normal.

PRECIPITATION.

The most prominent feature of the weather of the month was the almost universal deficiency in the precipitation.

Some heavy rains occurred near the beginning of the month at points in southern California and southwestern Arizona, and rains were fairly general during the first three or four days over the more eastern districts. Thereafter rainfall was scattered and greatly deficient until near the middle of the third decade, when heavy rains occurred over the greater part of Florida and lighter rains along the south Atlantic coast in connection with the severe West Indian hurricane that crossed the Florida Peninsula on the 25th and 26th. At the same time, general precipitation, rain or snow, set in over the western mountain districts and during the following few days overspread much of the central and northern Great Plains and extended into portions of the Mississippi and Ohio Valleys and Lake region. During the same period general rains set in over the far Northwest and extended eastward and southward over the greater part of the Plateau and Pacific coast States. The last few days of the month brought beneficial and greatly needed rains over many portions of the Gulf and Atlantic coast States and precipitation was more or less general as far west as the Mississippi River.

Over the Florida Peninsula the precipitation for the month was far in excess of the normal, due principally to the heavy falls in connection with the hurricane referred to previously, the monthly total exceeding 30 inches at the point of heaviest recorded rainfall. Some

heavy rains were reported along the coasts of Oregon and Washington, the maximum monthly amount exceeding 15 inches in extreme northwest Washington. In portions of the Great Lake region, Ohio Valley, New England, and some adjacent territory the monthly falls ranged from 2 to 4 inches, and over small areas in these districts the amounts for the month were slightly in excess of the normal. Elsewhere precipitation was usually far less than normal, and generally insufficient for local needs.

SNOWFALL.

In the mountain regions of the West snow occurred at most of the higher elevations, the total fall in portions of the Sierra amounting to a foot or more, and larger amounts were reported in the high mountains of Washington. In the Rocky Mountain system snow was general, the greatest depths, amounting to nearly 2 feet, being reported from southwestern Colorado. East of the Rocky Mountains snow occurred over most of the northern border States and in some cases as far south as the Ohio River, but the amounts were usually no more than traces.

RELATIVE HUMIDITY.

The generally dry condition of the atmosphere, apparent from the long periods without material precipitation, is clearly indicated by the negative departures from the normal of the average relative humidity for the month. In practically all portions of the country the relative humidity was less than the normal for the month, and in portions of the Great Plains and Rocky Mountain districts the averages were frequently from 10 to nearly 30 per cent deficient.

SEVERE LOCAL STORMS.

The table herewith contains such data as have been received concerning severe local storms that have occurred during the month. A more complete statement will appear in the Annual Report of the Chief of the Weather Bureau.

Place.	Date.	Time.	Width of path.	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
			Yards.					
Florida	23-25					Hurricane and tidal wave.	Severe West Indian hurricane passed over portion of State, causing large property damage and some loss of life. Full details elsewhere in this REVIEW.	Official, U. S. Weather Bureau.
Sacramento, Calif.	26	2:45 to 2:55 p. m.			$17,000	Small tornado	Considerable damage to roofs and buildings under construction.	Do.
Anglesea, N. J.	31	p. m.		11		Wind	Two fishing boats capsized, drowning 11 men	New York Tribune (New York, N. Y.).

STORMS AND WEATHER WARNINGS.

WASHINGTON FORECAST DISTRICT.

Storm warnings.—There was marked activity in the movement of areas of low pressure across the country during the greater part of the month, which was in striking contrast to the stagnant conditions that prevailed during October, 1920, and storm warnings were displayed on approximately half the days of the month on some portion of the Atlantic or East Gulf coasts or the Great Lakes.

The first disturbance of marked intensity that crossed the Washington district was central over western New York at 8 p. m. of the 7th, moving rapidly northeastward, and southwest storm warnings were issued at 9:30 p. m. for the Atlantic coast from Delaware Breakwater northward. The next warnings were issued for Lake Ontario and eastern Erie at 9:30 a. m. of the 9th in connection with a disturbance that was central over Lake Huron and moving rapidly eastward.

At noon of the 10th a disturbance of considerable intensity was central over western New York moving quite rapidly northeastward and southwest warnings were immediately ordered for the Atlantic coast from Delaware Breakwater northward.

The next storm of importance was central over lower Michigan on the morning of the 18th and moving northeastward, and southwest storm warnings were ordered for Lakes Huron, Erie, and Ontario. On the following day another disturbance was central over northern Lake Michigan, moving rapidly east-southeastward, and warnings were issued at 2 p. m. for Lakes Superior, Michigan, and northern Huron. Two days later still another disturbance of marked intensity moved rapidly eastward over northern Minnesota and the northern Lake region, and southwest storm warnings were issued at 9:30 p. m. of the 21st for Lake Superior and the northern portions of Lakes Michigan and Huron. The following morning the warnings were extended over Lakes Erie, Ontario, and southern Huron, and at 1:30 p. m. southwest warnings were issued for the Atlantic coast from Sandy Hook northward. The highest velocity reported in connection with this storm was 72 miles an hour from the southwest at Buffalo, N. Y.

On the 25th there was a strong area of high pressure over Ontario and a disturbance of marked intensity central over Kansas, moving slowly northeastward. At 5 p. m. northeast storm warnings were ordered for the Great Lakes, except Ontario and eastern Erie. This storm decreased greatly in intensity as it moved northeastward from Kansas to Minnesota and verifying velocities were reached at only a few stations.

Storm warnings were issued for the East Gulf coast and the Atlantic coast as far north as the Virginia Capes well in advance of the tropical storm that passed over the Florida Peninsula on the 25th. The complete history of this storm and the warnings issued in connection therewith are given on pages 567–570 of this REVIEW.

Frost warnings.—Warnings of frost were issued on numerous dates for various portions of the Washington forecast district. These warnings were for a limited area, as a rule, except on the 8th, 11th, 12th, and 13th, when they were for a considerable portion of the district.—*Charles L. Mitchell.*

CHICAGO FORECAST DISTRICT.

During the first half of October frost warnings were issued for that portion of the Chicago forecast district lying east of the Rocky Mountains on the 1st, 2d, 3dl 4th, 5th, 7th, 11th, and 12th, frosts being most genera, on the 3d, 4th, 8th, 12th, and 13th. On the 12th, killing frost was reported as far south as eastern Kansas and western and central Missouri. During the balance of the month the temperature was generally above the seasonal average throughout the district and no frost warnings were necessary.

On October 25 stock advices were issued for western Kansas.

The cranberry marsh season in Wisconsin terminated on October 4, but on October 1 and 3 frost warnings were issued, the lowest readings of the season with killing frost being reported on the morning of the 3d, 15° being registered on the marsh at Shell Lake, in the northwestern part of the State, and 19° at the marshes located in the central portion.

Special daily fire-weather warnings and forecasts were sent to the State Forester at St. Paul, Minn., from the beginning of the month to October 21, the service being discontinued on the latter date.—*E. H. Haines.*

NEW ORLEANS FORECAST DISTRICT.

No storm which would have called for warnings occurred along the middle and west Gulf coast during the month, and no warnings were displayed except at Burrwood and Pilottown on the 24th.

No cold waves occurred and no warnings were issued. Light frost occurred in some parts of the northern portion of the district on the 4th, 5th, 9th, 12th, 13th, 15th, 21st, and 27th, for which warnings were issued. A light frost occurred over the northern portion of the district on the 8th without warning, due to a more rapid movement southward of an area of high pressure than was anticipated.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

The month was unusually free from storms, and the precipitation was below the normal, except in parts of Utah. Remarkably warm weather prevailed throughout the district during the greater part of the month. Freezing temperature or killing-frost warnings were required, however, on several dates.

An anticyclonic area of considerable intensity appeared over the Province of Alberta on the 6th and moved rapidly southward along the eastern slope. It was anticipated that cloudy weather would prevail on the eastern slope on the morning of the 7th, and cloudy weather was reported, except in the extreme northern part of eastern Colorado where the weather cleared by morning and frost occurred. Warnings of freezing temperature or killing frost were also issued for eastern Colorado and frost for northern New Mexico on the morning of the 7th. A killing frost was reported at Pueblo and heavy frost at Santa Fe. Freezing temperature or frost was forecast for eastern Colorado and frost for northern New Mexico on the morning of the 11th, when an anticyclonic area occupied the eastern slope. Frost temperatures occurred in the area indicated. After a prolonged period of fair weather, a disturbance apparently formed over southern Nevada on the 21st and did not pass out of the district until four days later. On the 24th it occupied the Rocky Mountain region, with centers in northern Arizona and north-central Colorado. Freezing temperature warnings were issued for the western, fruit valleys of Colorado and for northern Arizona and the greater part of northern New Mexico and freezing temperature or killing-frost warnings for Utah. Freezing temperature occurred in the area indicated, with a killing frost at Modena, Utah. Warnings of freezing temperature or killing frost were repeated for the same area and extended to eastern Colorado on the morning of the 25th. Killing frosts were reported in the remainder of Utah and the western valleys of Colorado and freezing temperature in the remainder of the region for which the warnings were issued. A temperature of 38° was reported at Roswell, with clear sky. Although the barometer did not rise on the 27th the temperature fell to 34° at Roswell and a killing frost was reported. Warnings of local frost were issued for New Mexico on the 30th. Frost temperatures were reported throughout the State on the 31st.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

The month opened with quite heavy rain in southern California; and scattered light rains occurred in California and southern Nevada during the first week.

The pressure continued comparatively low over Alaska throughout the month, and consequently the storms from the north Pacific passed inland at a high latitude, the rain areas seldom extending south of the Siskiyou mountains or into the Plateau region.

On the 12th, a storm moved southeastwardly from the north Pacific, giving rain and strong southerly gales on the northern coast. From this time until the end of the month, storms of the Alaskan type moved southeastwardly at short intervals, but seldom affected the weather south of Cape Blanco. Many vessel reports were received by radio, and all tended to show very stormy conditions in the north Pacific during the latter half of the month. The Japanese S. S. *Fukui Maru* was seriously damaged in one of these gales and sank on the night of the 26th, about 350 miles off Cape Flattery. All passengers and crew were saved by the S. S. *West Ivan.*

Storm warnings were ordered 11 times during the month and were generally verified. Reports at sea showed them all to be justified.

Special rain warnings were issued in northern California on the 3d and 12th.

A period of warm weather prevailed over the southern half of this district from the 17th to the 20th, and on the 18th the record for high temperature in October was broken at San Luis Obispo and Tonopah.

During the storm of the 26th a small tornado occurred in the suburbs of Sacramento, slightly injuring five persons, unroofing several buildings and causing damage estimated at about $17,000.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

Normal October low-water conditions were accentuated by the prevailing drought throughout the month, and only two minor floods were reported. On the first day of the month the Santee River at Rimini, S. C., reached the flood stage of 12 feet from local rains, with the upper river falling at the same time. No damage

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was done. On the last day of the month there was a short flood in the upper waters of the Roanoke River, due to a heavy two-day rain, and considerable local damage resulted.

In the Southeastern States the water shortage became so acute as to necessitate the shutting down of many hydroelectric plants, and in some instances the overland hauling of water for steam purposes.

The daily forecasts of stages of water in the great rivers of the country have taken on an added importance by reason of the impetus recently given to river transportation through the extension of the barge service on the Mississippi and Ohio Rivers. On October 27, 1921, a fleet of 10 barges, carrying 8,000 tons of steel products, departed from Pittsburgh, Pa., for St. Louis, Mo., and extensions of the service north of St. Louis and further extensions south of Cairo, Ill., are planned for the near future.

The barges have a net tonnage of from 800 to 1,000 tons, and will probably have a draft of only 4 feet of water. The towboats will have about the same draft.

MEAN LAKE LEVELS DURING OCTOBER, 1921.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Nov. 4, 1921.]

The following data are reported in the "Notice to Mariners" of the above date:

Date.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.53	579.86	571.79	245.11
Above or below—				
Mean stage of September, 1921	−0.14	−0.18	−0.38	−0.32
Mean stage of October, 1920	−0.15	−0.69	−0.26	−0.18
Average stage for October, last 10 years	−0.16	−0.65	−0.38	−0.71
Highest recorded October stage	−1.03	−3.08	−1.91	−2.70
Lowest recorded October stage	+0.95	+0.26	+0.99	+1.44
Average relation of the October level to:				
September level		−0.20	−0.30	−0.40
November level		+0.20	+0.30	+0.20

[1] Lake St. Clair's level: In October, 574.65 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS: OCTOBER, 1921.

By J. WARREN SMITH, Meteorologist.

The first half of October was cool for the season in the eastern half of the country, but for the month as a whole temperatures were above normal in nearly all sections. Some frost damage was done to tender vegetation during the first decade, and near the middle of the month killing frost occurred as far south as the northern portions of Oklahoma, Arkansas, and Tennessee, but a comparatively small amount of harm resulted, as crops were mostly mature. The month was unusually favorable for outdoor operations, except for some interruption from the upper Mississippi Valley eastward by rather frequent rainfall. From the 4th to the 25th fair weather prevailed throughout much the greater portion of the country.

The weather was more favorable for drying corn in the lower Missouri, central and upper Mississippi, and the Ohio Valley districts, and practically no damage was done by frost. Husking made satisfactory progress and, by the last decade of the month, this work was reported as well along in the Ohio Valley and about half done in Iowa. Much of the month was exceptionally favorable for drying the crop in good condition for cribbing.

Cotton bolls continued to open rapidly and the weather was very favorable for picking and ginning in all sections of the cotton belt. The rainfall early in the month was beneficial in checking deterioration in North Carolina, but little or no top crop was realized in any portion of the belt. Late cotton improved in portions of North Carolina and the yield was exceeding expectations in northern South Carolina; otherwise little or no improvement was reported in this crop during the month.

Less rain and more sunshine were favorable for seeding winter grains in the central and eastern portions of the winter-wheat belt, where frequent rains had previously caused considerable delay. Soil moisture conditions were satisfactory in the western portion of the belt during the early part of the month, but wheat in that area was unfavorably affected thereafter by dry weather, while it was generally too dry for seeding and germination from the Rocky Mountains westward and in many of the more eastern districts. The drought had become especially severe by the close of the month in the southwestern Great Plains, including most of western Kansas, and from Oklahoma and southeastern Colorado southward, where it was too dry for seeding and germination, and the wheat that was up showed steady deterioration.

Conditions were favorable for meadows, pastures, and late truck in the interior valley districts, but lack of moisture was harmful in most of the South, the Southwest, and many western localities. Frost did some damage to late truck in California the latter part of the month, while at the same time sugar cane was considerably damaged in parts of Florida by heavy rains and high winds.

The weather was generally favorable for fruit, except that heavy damage resulted to citrus fruit in parts of Florida from the tropical storm of the 25th and 26th. (See pp. 567–570 of this REVIEW.)

CLIMATOLOGICAL TABLES.*

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation, by sections, October, 1921.

Section.	Temperature.								Precipitation.					
			Monthly extremes.								Greatest monthly.		Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Section average.	Departure from the normal.	Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	63.0	−1.8	3 stations	91	2†	Valley Head	29	14	2.30	−0.40	Milstead	5.13	Demopolis	0.45
Arizona	65.3	+3.1	Gila Bend	109	20	3 stations	15	28	0.92	+0.03	Seligman	3.70	5 stations	0.00
Arkansas	61.6	−0.7	2 stations	96	19	2 stations	27	8†	0.72	−2.28	Springbank	1.47	2 stations	T.
California	62.7	+1.6	Greenland Ranch	109	2	Pertola	14	26	0.85	−0.60	Crescent City	5.13	6 stations	0.00
Colorado	50.2	+4.4	2 stations	95	5†	Crested Butte	−9	24	0.92	−0.47	Sedgwick	2.85	Del Norte	T.
Florida	72.7	−0.7	4 stations	96	2†	De Funiak Springs	36	8	9.05	+3.87	Fort Lauderdale	31.34	Jasper	1.15
Georgia	63.1	−1.7	Westboro	92	2	Blue Ridge	25	14	2.12	−0.70	West Point	4.22	Augusta	0.55
Hawaii	73.2	−0.4	Mahukona, Hawaii	94	19†	Volcano Observatory	49	19	5.87	+0.80	Papaikou, Hawaii	18.19	Mana Pump, Kauai	0.18
Idaho	50.1	+3.9	Gooding	91	2	Felt	9	26	0.73	−0.67	Wallace	2.91	Arco	T.
Illinois	55.8	+0.6	Mt. Carmel	86	24†	2 stations	27	8†	2.38	−0.20	Freeport	4.42	Cairo	0.82
Indiana	54.8	+0.2	Rome	88	25	Marengo	21	14	2.85	+0.15	Notre Dame	6.28	Elliston	0.52
Iowa	54.6	+3.8	Clarinda	90	16	Bedford	21	12	1.97	−0.49	Mount Ayr	3.61	Rock Rapids	0.21
Kansas	59.9	+3.1	2 stations	100	9	Leoti	21	27	0.65	−1.27	Wheaton	2.09	La Crosse	0.00
Kentucky	57.1	−0.7	Bowling Green	90	25	2 stations	24	13	2.29	−0.21	Greensburg	4.73	Cynthiana	0.40
Louisiana	67.6	0.0	2 stations	98	19	2 stations	31	9	1.79	−1.40	Covington	6.00	2 stations	0.00
Maryland-Delaware	55.9	−0.5	2 stations	85	10†	Oakland, Md	20	14	1.08	−1.79	Oakland, Md	2.62	Keedysville, Md	0.51
Michigan	49.3	+0.7	Traverse City	82	16	Deer Park	14	21	2.92	+0.25	Muskegon	5.88	Mount Pleasant	0.18
Minnesota	48.4	+3.0	Lynd	84	15	Red Lake	12	31	0.60	−1.48	Grand Meadow	1.76	Red Lake	0.00
Mississippi	64.3	−0.7	2 stations	94	19†	Monticello	30	9	1.24	−1.45	Pearlington	4.29	Holly Bluff	0.16
Missouri	57.9	+0.8	Caruthersville	92	24	Dean	24	12	2.19	−0.40	Macon	5.28	Doniphan	0.36
Montana	48.9	+5.0	Billings	90	4	Browning	10	27	0.36	−0.78	Heron	2.66	13 stations	0.00
Nebraska	55.3	+4.3	Culbertson	97	21	Gordon	11	11	1.18	−0.40	Auburn	4.50	Minden	0.05
Nevada	55.9	+4.9	Logandale	99	12	2 stations	12	25†	0.25	−0.40	Searchlight	1.91	5 stations	0.00
New England	49.7	+1.2	Somerset, Vt	90	15	Cavendish, Vt	11	26	2.35	−1.31	Ashland, Me	6.11	Norwalk, Conn	0.99
New Jersey	54.1	−0.9	Tuckerton	82	2	Charlotteburg	16	27	0.97	−2.76	Culvers Lake	2.18	Long Branch	0.33
New Mexico	56.3	+2.9	Pearl (near)	100	9	Senorito	12	26	0.30	−0.91	Schuster Springs R. S.	1.83	20 stations	0.00
New York	50.4	+0.5	Chazy	83	1	Indian Lake	13	27	2.62	−0.74	Canton	4.90	New York City	0.74
North Carolina	59.4	−0.6	2 stations	89	3†	Jefferson	20	14	2.54	−0.97	Marion	7.76	Elizabeth City	0.45
North Dakota	47.2	+3.4	Skaar	88	20	2 stations	16	11	0.68	−0.32	Linton	2.65	Parshall	0.00
Ohio	53.7	+0.2	2 stations	85	19†	3 stations	23	13†	2.18	−0.52	Hudson	4.15	Catawba Island	0.76
Oklahoma	64.0	+2.6	4 stations	97	2†	2 stations	26	8	0.24	−2.45	Broken Bow	1.73	6 stations	0.00
Oregon	53.1	+2.5	Grants Pass	99	9	Lapine	10	1	2.12	+0.07	Jewell	7.98	Blitzen	T.
Pennsylvania	52.6	+0.1	Everett	84	3	2 stations	18	26†	2.16	−1.21	Summit	6.55	Philadelphia	0.40
South Carolina	62.6	−1.0	2 stations	90	2†	Santuck	27	14	1.79	−1.23	Landrum	4.44	Trenton	0.20
South Dakota	51.3	+3.3	Yankton	90	7	3 stations	14	10†	0.91	−0.71	Rosebud Agency	2.62	3 stations	T.
Tennessee	57.7	−2.1	2 stations	88	24†	3 stations	24	13†	2.14	−0.83	Sewanee	4.11	Dandridge	0.69
Texas	68.6	+1.1	Coleman	101	16†	Clint	20	29	0.57	−2.05	Hitchcock	5.06	28 stations	0.00
Utah	53.8	+5.0	Springdale	96	20	Great Basin (Alpine)	6	25	1.24	−0.10	New Harmony	3.06	Wendover	0.01
Virginia	57.3	−0.2	Mayhurst	87	25	Burkes Garden	20	22	1.96	−1.16	Catawba Sanatorium	6.19	Langley Field	0.38
Washington	51.2	+1.9	Trinidad	93	9	Republic	15	23	3.44	+0.73	Forks	25.87	Sunnyside	0.17
West Virginia	53.7	−1.4	2 stations	88	11†	2 stations	21	14	2.48	−0.36	Pickens	5.76	Upper Tract	0.30
Wisconsin	49.1	+1.3	Grantsburg	80	15	2 stations	18	4†	2.05	−0.40	Lake Mills	5.34	Danbury	0.40
Wyoming	47.9	+5.0	Fort Laramie	90	4	South Pass City	6	28	0.33	−0.78	Border	1.28	Lovell	0.00

* For description of tables and charts, see REVIEW, January, 1921, p. 41.

† Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1921.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.							
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*									*0–10*	*In.*	*In.*
New England.							**52.1**	**+ 1.8**											**75**	**1.98**	**− 1.6**											**5.1**		
Eastport	76	67	85	29.82	29.90	− .10	49.3	+ 2.7	69	2	56	28	26	43	25	46	42	79	1.66	− 2.2	7	8,749	sw.	37	se.	20	11	8	12	5.4	T.	0.0
Greenville, Me.	1,070	6	....	28.74	29.90	.....	45.4	.....	73	15	55	25	29	36	30	.....	.....	.....	.....	4.82	.....	14	.....	.....	.....	.....	.....	9	7	15	.....	T.	0.0
Portland, Me.	103	82	117	29.83	29.95	− .09	50.8	+ 1.7	76	15	60	31	26	42	30	45	40	71	2.18	− 1.5	8	6,510	sw.	36	se.	10	15	5	11	4.8	0.0	0.0
Concord	288	70	79	29.65	29.96	− .09	49.5	+ 0.8	76	15	62	23	26	38	43	.....	.....	.....	.....	2.09	− 1.2	7	3,662	w.	25	w.	12	13	10	8	4.4	0.0	0.0
Burlington	404	11	48	29.50	29.95	− .09	48.2	+ 1.3	72	2	57	23	26	39	31	.....	.....	.....	.....	3.78	+ 0.6	10	8,456	s.	40	s.	18	8	7	16	6.4	T.	0.0
Northfield	876	12	60	29.00	29.96	− .08	45.8	+ 2.2	72	15	58	16	26	34	41	41	37	79	2.69	+ 0.2	10	5,256	s.	31	s.	7	8	8	15	6.2	0.8	0.0
Boston	125	115	188	29.82	29.96	− .09	55.2	+ 2.9	79	15	64	31	26	47	29	48	42	67	1.24	− 2.6	6	7,518	w.	39	w.	8	12	12	7	4.7	0.0	0.0
Nantucket	12	14	90	29.96	29.97	− .08	57.0	+ 2.5	73	3	63	40	27	51	21	52	48	76	2.13	− 1.3	6	11,847	sw.	54	sw.	8	13	8	10	5.1	0.0	0.0
Block Island	26	11	46	29.95	29.98	− .07	55.7	+ 0.4	72	2	62	37	26	50	21	52	48	80	2.06	− 2.0	5	13,198	sw.	60	nw.	8	14	6	11	4.6	0.0	0.0
Providence	160	215	251	29.79	29.96	− .09	54.0	+ 1.8	77	2	63	30	26	45	28	48	42	69	1.23	− 2.6	6	8,930	w.	54	w.	8	14	10	7	4.5	0.0	0.0
Hartford	159	122	140	29.80	29.98	− .08	53.2	+ 2.0	76	2	64	29	27	43	32	47	42	73	1.19	− 2.7	5	5,413	sw.	42	s.	10	9	10	12	5.7	0.0	0.0
New Haven	106	74	153	29.87	29.99	− .07	54.3	+ 1.5	76	2	64	30	26	44	30	49	45	77	1.53	− 2.4	6	6,819	w.	38	s.	10	13	13	5	3.9	0.0	0.0
Middle Atlantic States.							**56.2**	**+ 0.5**											**72**	**1.65**	**+ 1.6**											**4.1**		
Albany	97	102	115	29.87	29.97	− .09	52.2	+ 1.8	75	2	62	27	27	42	33	46	42	75	1.59	− 1.4	7	5,128	s.	37	s.	7	12	9	10	5.1	0.0	0.0
Binghamton	871	10	84	29.05	29.99	− .07	51.5	+ 2.3	76	2	63	25	26	40	41	.....	.....	.....	.....	2.91	− 0.2	11	4,062	w.	25	sw.	22	11	7	13	5.7	0.0	0.0
New York	314	414	454	29.66	30.00	− .08	56.2	+ 0.6	74	2	64	38	26	49	24	49	44	67	0.74	− 3.0	6	12,318	s.	63	nw.	20	9	16	6	5.0	0.0	0.0
Harrisburg	374	94	104	29.63	30.03	− .05	54.8	+ 0.8	76	7	65	33	27	45	32	47	42	68	1.51	− 1.4	6	4,448	w.	25	sw.	9	15	10	6	3.9	0.0	0.0
Philadelphia	117	123	190	29.90	30.03	− .04	57.7	+ 1.4	78	7	67	36	26	49	28	51	47	74	0.40	− 2.7	5	6,312	nw.	30	s.	10	14	12	5	4.1	0.0	0.0
Reading	325	81	98	29.67	30.03	.....	55.1	.....	77	2	65	32	27	45	33	48	43	71	1.59	− 1.8	6	2,481	nw.	20	nw.	5	15	13	3	4.2	0.0	0.0
Scranton	805	111	119	29.13	30.00	− .07	52.6	+ 1.2	73	2	63	28	26	42	36	46	42	74	2.78	− 0.1	10	4,884	sw.	31	sw.	23	11	13	7	4.8	0.0	0.0
Atlantic City	52	37	48	29.96	30.02	− .05	56.8	− 0.6	73	2	64	38	13	50	22	52	49	78	1.37	− 1.9	4	5,597	w.	26	s.	10	17	10	4	3.3	0.0	0.0
Cape May	18	13	49	30.03	30.05	− .02	58.3	− 1.3	74	2	66	39	26	51	25	53	49	75	1.62	− 1.7	5	7,231	nw.	36	nw.	20	15	7	9	4.5	0.0	0.0
Sandy Hook	22	10	55	29.98	30.00	.....	56.0	.....	74	2	62	39	26	50	22	50	46	75	0.49	.....	4	11,248	sw.	50	s.	10	11	15	5	4.4	0.0	0.0
Trenton	190	159	183	29.80	30.00	.....	55.0	.....	77	7	66	33	26	45	32	48	43	70	0.34	− 3.1	5	7,834	w.	44	sw.	10	11	11	9	4.7	0.0	0.0
Baltimore	123	100	113	29.88	30.02	− .06	57.8	+ 0.3	78	10	67	38	26	48	27	50	45	67	1.61	− 1.4	5	4,215	sw.	22	w.	12	20	7	4	3.3	0.0	0.0
Washington	112	62	85	29.90	30.02	− .06	57.0	+ 0.4	79	10	68	36	14	46	36	49	44	69	1.35	− 1.7	6	4,510	nw.	30	nw.	12	18	8	5	3.6	0.0	0.0
Lynchburg	681	153	188	29.30	30.04	− .05	57.6	+ 0.7	86	25	71	31	14	44	42	49	45	71	2.45	− 0.9	4	5,671	nw.	37	nw.	20	22	7	2	2.5	0.0	0.0
Norfolk	91	170	205	29.94	30.04	− .03	62.0	+ 0.7	81	3	71	40	14	53	28	54	50	72	1.28	− 2.6	4	10,264	ne.	54	nw.	8	16	6	9	4.1	0.0	0.0
Richmond	144	11	52	29.89	30.05	− 0.3	59.5	− 0.3	83	25	72	33	14	47	43	51	45	68	1.20	− 2.1	4	6,017	sw.	30	sw.	9	17	10	4	3.4	0.0	0.0
Wytheville	2,304	49	56	27.67	30.06	− .06	52.2	− 1.4	79	25	64	26	14	40	40	45	40	71	3.69	+ 0.6	8	4,965	w.	27	w.	8	20	6	5	3.1	0.0	0.0
South Atlantic States.							**63.5**	**− 0.2**											**71**	**2.30**	**− 1.4**											**3.9**		
Asheville	2,255	70	84	27.71	30.08	− .01	54.2	− 1.1	79	10	67	28	14	42	40	45	40	70	2.25	− 0.7	9	5,589	nw.	33	nw.	19	20	7	4	2.8	0.0	0.0
Charlotte	779	55	62	29.20	30.04	− .04	60.8	− 0.3	83	3	72	38	9	50	33	51	44	60	1.76	− 1.4	4	3,755	ne.	25	nw.	3	19	5	7	3.1	0.0	0.0
Hatteras	11	12	50	30.00	30.01	− .05	65.6	− 0.4	83	3	72	49	9	60	25	61	57	75	5.07	− 0.9	7	11,448	ne.	50	nw.	8	14	6	11	4.7	0.0	0.0
Manteo	12	5	42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Raleigh	376	103	110	29.64	30.04	− .03	60.8	+ 0.3	83	11	72	35	9	50	34	53	47	69	1.05	− 2.4	4	6,430	ne.	31	nw.	8	18	6	7	3.9	0.0	0.0
Wilmington	78	81	91	29.95	30.03	− .03	63.7	+ 0.4	83	3	73	42	9	54	28	57	53	73	2.82	− 0.9	9	5,874	ne.	30	ne.	26	14	10	7	4.2	0.0	0.0
Charleston	48	11	92	29.96	30.01	− .05	66.6	− 0.5	87	3	74	49	5	59	23	60	57	76	1.70	− 2.2	8	8,792	ne.	43	ne.	26	16	6	9	4.4	0.0	0.0
Columbia, S. C.	351	41	57	29.66	30.05	− .02	63.4	− 0.6	86	3	75	39	9	52	38	54	47	64	0.45	− 2.4	4	5,178	ne.	27	sw.	31	20	4	7	3.6	0.0	0.0
Greenville, S. C.	1,039	113	122	28.93	30.03	.....	60.0	.....	79	23	70	37	9	50	32	52	47	69	2.56	.....	7	6,217	ne.	33	ne.	26	21	7	3	2.5	0.0	0.0
Augusta	180	62	77	29.84	30.03	− .04	63.6	0.0	87	3	76	40	9	52	36	56	51	72	0.55	− 1.8	6	4,152	nw.	28	ne.	26	16	8	7	3.7	0.0	0.0
Savannah	65	150	194	29.94	30.01	− .04	66.8	+ 0.5	86	3	75	47	9	58	27	59	55	75	0.95	− 2.6	9	8,800	ne.	43	ne.	26	15	5	11	4.9	0.0	0.0
Jacksonville	43	209	245	29.93	29.98	− .04	69.2	− 0.4	87	2	76	48	9	62	24	64	61	81	6.37	+ 1.3	10	9,076	n.	64	ne.	25	11	10	10	5.3	0.0	0.0
Due west	711	10	55	29.30	30.07	.....	60.6	.....	82	3	72	37	14	49	37	.....	.....	.....	.....	1.93	.....	5	6,350	ne.	36	ne.	26	18	8	5	3.3	0.0	0.0
Florida Peninsula.							**77.1**	**+ 0.4**											**81**	**11.87**	**+ 5.6**											**7.1**		
Key West	22	10	64	29.88	29.90	− .04	79.6	+ 0.9	89	3	84	71	1	876	14	74	72	81	7.54	+ 2.2	22	7,743	se.	48	sw.	25	6	9	16	6.9	0.0	0.0
Miami	25	71	79	29.91	29.94	.....	77.2	− 0.6	87	3	82	68	5	72	16	73	71	84	18.20	+ 7.7	19	6,290	e.	35	sw.	25	2	12	17	7.7	0.0	0.0
Sand Key	23	39	72	29.88	29.91	− .03	78.4	.....	85	3	81	70	13	76	12	75	73	81	10.61	.....	19	10,650	se.	56	s.	25	6	7	18	7.1	0.0	0.0
Tampa	35	79	92	29.89	29.93	− .05	74.6	+ 0.8	90	2	82	54	9	67	28	68	65	79	9.88	+ 6.9	8	6,314	ne.	68	s.	25	4	15	12	6.7	0.0	0.0
East Gulf States.							**65.0**	**− 0.5**											**68**	**1.95**	**− 0.9**											**3.1**		
Atlanta	1,174	190	216	28.81	30.05	− .02	61.0	− 1.4	80	23	71	40	14	51	27	53	47	66	2.85	+ 0.5	6	8,677	nw.	40	nw.	4	19	3	9	3.7	0.0	0.0
Leesburg	279	10	55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Macon	370	78	87	29.63	30.03	− .03	62.9	− 0.8	86	3	75	37	9	51	39	64	48	66	1.66	− 0.5	5	4,838	ne.	30	nw.	4	21	3	7	3.4	0.0	0.0
Thomasville	273	49	58	29.70	30.00	− .04	67.0	− 1.2	87	2	78	44	9	56	34	58	53	68	1.68	− 1.8	7	3,653	ne.	17	nw.	3	12	10	9	5.0	0.0	0.0
Pensacola	56	149	185	29.94	30.00	− .03	68.4	− 1.0	86	3	76	51	13	61	21	61	56	69	2.20	− 1.9	4	9,664	ne.	40	n.	8	20	8	3	3.0	0.0	0.0
Anniston	741	9	57	29.27	30.07	.00	60.6	− 1.8	84	24	74	35	9	48	39	.....	.....	.....	2.92	+ 0.6	8	3,951	se.	22	nw.	4	21	5	5	2.5	0.0	0.0
Birmingham	700	11	48	29.29	30.06	− .01	62.8	− 1.6	85	19	75	40	21	51	34	52	47	66	1.94	− 0.4	7	4,365	n.	22	se.	29	21	5	5	2.9	0.0	0.0
Mobile	57	125	161	29.94	30.00	− .04	68.0	+ 0.9	89	3	78	48	9	58	32	59	54	70	1.42	− 1.8	3	7,256	n.	36	n.	8	16	13	2	3.3	0.0	0.0
Montgomery	223	100	112	29.79	30.04	− .02	64.7	− 1.0	85	19	76	45	13	53	33	56	50	66	2.87	+ 0.4	5	4,425	ne.	22	n.	8	20	6	5	2.8	0.0	0.0
Corinth	469	6	....	.....	.....	.....	60.8	.....	88	19	76	33	14	45	45	.....	.....	.....	3.02	.....	5	.....	se.	.....	.....	.....	18	8	5	.....	0.0	0.0
Meridian	375	85	93	29.62	30.02	− .04	63.3	+ 0.4	87	19	76	38	9	51	39	54	48	68	1.20	− 1.5	6	3,592	ne.	20	nw.	7	20	8	3	2.5	0.0	0.0
Vicksburg	247	65	73	29.76	30.04	− .02	65.6	+ 0.3	88	19	77	42	13	55	31	56	51	69	0.86	− 1.9	2	4,585	n.	30	w.	28	23	4	4	2.5	0.0	0.0
New Orleans	53	76	84	29.94	30.00	− .03	71.2	+ 1.7	88	2	79	53	31	63	22	62	57	67	1.85	− 1.1	2	5,026	ne.	28	s.	28	20	9	2	2.6	0.0	0.0
West Gulf States.							**67.5**	**+ 0.9**											**65**	**0.66**	**− 2.1**											**2.1**		
Shreveport	249	77	93	29.75	30.02	− .03	66.8	+ 1.2	94	19	79	42	8	54	32	56	49	64	0.03	− 3.2	1	4,575	n.	26	w.	29	23	7	1	2.0	0.0	0.0
Bentonville	1,303	11	44	.....	.....	.....	59.2	+ 1.2	85	9	73	30	12	46	36	.....	.....	.....	0.69	.....	4	.....	.....	.....	.....	.....	24	3	4	.....	0.0	0.0
Fort Smith	457	79	94	29.51	29.99	− .06	63.2	+ 1.5	86	2	76	37	8	50	39	52	45	62	0.13	− 2.7	3	6,159	e.	42	sw.	29	21	7	3	2.5	0.0	0.0
Little Rock	357	136	144	29.64	30.01	− .05	62.9	0.0	85	19	75	41	8	51	31	53	47	64	0.14	− 2.4	3	5,708	s.	42	nw.	2	23	4	4	2.3	0.0	0.0
Brownsville	57	4	26	.....	.....	.....	75.8	.....	93	2	87	51	30	64	31	.....	.....	.....	1.90	.....	2	.....	n.	.....	.....	.....	.....	.....	.....	.....	.....	0.0	0.0
Corpus Christi	20	69	77	29.97	29.99	− .01	74.6	+ 2.0	92	28	83	53	29	66	29	67	63	75	0.08	− 2.0	3	7,378	n.	40	n.	28	28	3	0	1.3	0.0	0.0
Dallas	512	109	117	29.46	30.00	.....	67.4	.....	95	19	80	42	8	55	38	.....	.....	.....	0.34	.....	3	6,403	se.	29	w.	28	24	5	2	2.1	0.0	0.0
Fort Worth	670	106	114	29.28	29.98	− .05	67.9	+ 1.6	94	19	80	39	8	55	39	55	47	57	0.31	− 2.2	3	7,407	s.	35	nw.	28	25	5	1	1.7	0.0	0.0
Galveston	54	106	114	.....	30.02	− .01	72.2	− 0.2	86	2	77	53	31	67	17	.....	.....	.....	3.83	− 0.4	4	6,766	ne.	36	w.	28	26	3	2	.....	0.0	0.0
Groesbeck	461	11	56	29.53	30.01	.....	66.6	.....	94	19	81	40	8	52	43	.....	.....	.....	0.77	.....	2	6,773	s.	33	n.	7	21	9	1	2.3	0.0	0.0
Houston	138	111	121	29.86	30.01	.....	70.4	+ 0.5	90	19	81	48	31	60	30	.....	.....	.....	1.15	.....	3	5,226	se.	25	n.	8	21	10	0	2.0	0.0	0.0
Palestine	510	64	72	29.49	30.02	− .01	67.1	+ 0.9	94	19	79	43	8	55	31	55	48	59	0.21	− 3.4	1	4,730	s.	33	nw.	2	23	6	2	2.4	0.0	0.0
Port Arthur	34	58	66	29.96	30.00	.....	69.5	.....	90	19	79	49	31	60	26	62	58	75	1.28	.....	4	5,861	ne.	29	w.	28	25	4	2	1.8	0.0	0.0
San Antonio	701	119	132	29.29	30.01	.00	70.4	+ 1.2	90	2	82	48	31	58	31	59	53	63	1.02	− 0.5	2	5,017	n.	31	n.	3	22	8	1	1.8	0.0	0.0
Taylor	582	59	63	29.43	30.04	+ .02	68.1	− 0.2	93	19	81	46	8	55	36	.....	.....	.....	0.20	− 2.4	3	5,014	s.	26	nw.	29	23	6	2	2.5	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1921*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.							
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee.							56.5	% 0.4											70	2.15	− 0.4										4.9		
Chattanooga	762	189	213	29.24	30.06	− .03	58.8	− 5.0	79	24	70	37	9	48	35	50	45	68	8	4,912	nw.	32	nw.	19	21	7	3	2.9	0.0	0.0
Knoxville	996	102	111	29.00	30.06	− .03	57.8	− 0.3	81	25	70	35	13	46	36	49	43	67	8	4,001	ne.	28	nw.	19	20	7	4	3.2	0.0	0.0
Memphis	399	76	97	29.63	30.06	− .01	62.9	+ 0.4	84	25	73	40	8	53	33	54	48	66	6	5,685	se.	33	sw.	29	23	4	4	2.3	0.0	0.0
Nashville	546	168	191	29.47	30.06	− .02	58.5	− 1.8	83	24	70	35	14	46	37	50	44	68	7	6,114	nw.	36	nw.	7	20	6	5	2.9	0.0	0.0
Lexington	989	193	230	28.97	30.03	− .05	56.8	+ 0.3	78	24	66	36	12	48	32				8	9,720	sw.	38	nw.	7	16	10	5	3.5	0.0	0.0
Louisville	525	219	255	29.46	30.04	− .04	58.0	− .04	82	25	68	35	13	48	33	49	43	67	7	8,291	s.	37	s.	10	20	6	5	3.1	0.0	0.0
Evansville	431	139	175	29.56	30.04	− .04	58.6	+ 0.6	83	25	69	37	8	48	31	50	44	65	8	7,984	sw.	40	s.	27	18	10	3	3.2	0.0	0.0
Indianapolis	822	194	230	29.11	30.00	− .07	54.9	− 0.1	78	24	64	36	8	46	30	48	43	71	8	9,200	sw.	36	w.	19	17	3	11	4.5	0.0	0.0
Royal Center	736	11	55	29.17	29.98	.....	53.3	.....	79	17	63	31	13	43	29	.....	.....	.....	15	7,720	sw.	39	w.	19	9	11	11	5.2	0.0	0.0
Terra Haute	575	96	129	29.36	29.97	.....	56.7	.....	80	17	66	36	8	47	29	48	43	69	11	7,370	s.	31	nw.	19	10	11	10	5.0	0.0	0.0
Cincinnati	628	11	51	29.35	30.03	− .05	55.2	+ 0.2	80	24	66	28	13	44	35	.....	.....	.....	9	5,176	sw.	28	n.	31	16	5	10	4.2	T.	0.0
Columbus	824	179	222	29.14	30.02	− .06	54.2	+ 0.1	78	24	64	33	13	44	30	47	43	72	12	8,165	sw.	36	nw.	7	13	8	10	4.7	T.	0.0
Dayton	899	181	216	29.02	29.98	.....	54.2	+ 0.1	77	24	64	33	13	45	29	48	43	72	10	7,860	sw.	35	ne.	30	16	6	9	4.4	T.	0.0
Elkins	1,947	59	67	27.99	30.08	− .02	51.3	− 0.1	77	24	64	27	14	38	44	43	40	83	10	3,975	w.	25	w.	7	15	6	10	4.9	T.	0.0
Parkersburg	638	77	84	29.38	30.05	− .03	55.7	+ 0.8	79	24	67	31	13	44	38	47	43	73	8	4,000	sw.	29	nw.	7	14	8	9	4.4	0.0	0.0
Pittsburgh	842	353	410	29.11	30.02	− .06	54.0	− 0.9	74	24	64	35	13	45	33	47	43	73	8	8,843	sw.	37	ws.	18	12	5	14	5.4	T.	0.0
Lower Lake Region.							52.4	+ 0.6											73	2.78	− 0.2										5.6		
Buffalo	767	247	280	29.12	29.95	− .10	52.2	+ 0.7	71	17	59	32	26	45	26	46	42	71	13	13,788	w.	70	sw.	22	8	5	18	6.7	0.0	0.0
Canton	448	10	61	29.44	29.92	.....	47.8	+ 0.6	73	18	57	23	26	39	34	.....	.....	.....	16	7,837	sw.	46	w.	22	12	8	11	5.3	T.	0.0
Oswego	335	76	91	.....	29.95	− .10	51.4	+ 0.2	71	18	58	32	26	44	29	.....	.....	.....	16	7,364	s.	32	nw.	22	10	4	17	.....	0.0	0.0
Rochester	523	86	102	29.39	29.97	− .08	52.4	+ 1.6	76	18	60	34	26	44	27	46	41	70	13	6,358	sw.	40	w.	22	9	7	15	6.1	0.0	0.0
Syracuse	597	97	113	29.33	29.97	− .09	51.5	+ 0.5	73	2	60	29	26	44	28	.....	.....	.....	14	8,288	s.	43	sw.	22	7	7	17	6.6	T.	0.0
Erie	714	130	166	29.19	29.98	− .09	53.5	+ 0.4	74	17	61	35	26	46	25	47	42	69	11	11,601	sw.	50	se.	27	11	9	11	5.2	1.0	0.0
Cleveland	762	190	201	29.15	29.98	− .08	53.6	+ 0.5	77	17	61	37	13	46	30	47	42	71	14	11,260	s.	49	nw.	8	11	7	13	5.5	T.	0.0
Sandusky	629	62	103	29.28	29.97	− .09	54.1	+ 0.2	79	17	62	33	13	46	29	.....	.....	.....	11	9,977	sw.	39	nw.	8	10	8	13	5.2	T.	0.0
Toledo	628	208	243	29.29	29.98	− .07	53.4	+ 0.8	78	17	62	34	13	45	30	47	42	73	10	11,329	sw.	56	sw.	18	13	6	12	4.9	0.0	0.0
Fort Wayne	856	113	124	29.06	29.99	.....	53.6	− 0.1	79	17	62	34	13	45	33	48	45	80	10	7,677	sw.	29	w.	19	10	11	10	5.4	T.	0.0
Detroit	730	218	245	29.17	29.97	− .08	52.4	+ 0.7	74	17	60	33	13	45	26	47	43	75	14	9,287	sw.	42	sw.	18	15	3	13	4.8	0.0	0.0
Upper Lake Region.							49.5	+ 1.9											79	2.73	0.0										6.0		
Alpena	609	13	92	29.27	29.94	− .09	48.4	+ 2.5	70	5	55	30	21	42	35	44	41	82	14	8,677	nw.	44	nw.	22	3	12	16	7.0	T.	0.0
Escanaba	612	54	60	29.26	29.94	− .07	47.2	+ 2.1	70	5	54	30	8	41	29	43	40	81	10	7,218	nw.	36	n.	19	6	11	14	6.5	T.	0.0
Grand Haven	632	54	89	29.25	29.93	− .10	51.8	+ 1.6	68	17	58	32	12	45	25	48	44	78	16	9,790	sw.	41	w.	18	10	12	9	5.4	0.7	0.0
Grand Rapids	707	70	87	29.18	29.96	− .08	52.0	+ 2.0	72	16	60	34	13	44	27	47	43	79	13	4,681	s.	26	w.	22	7	13	11	5.8	T.	0.0
Houghton	684	62	99	29.18	29.91	− .09	47.6	+ 2.5	70	14	54	30	8	42	31	.....	.....	.....	13	6,849	w.	52	w.	22	2	12	17	7.5	2.1	0.0
Lansing	878	11	62	29.00	29.96	.....	50.5	+ 1.8	75	17	60	29	13	40	31	45	42	84	17	4,569	sw.	20	nw.	12	13	9	9	5.3	T.	0.0
Ludington	637	60	66	29.23	29.93	.....	50.9	.....	67	16	57	36	12	45	21	47	44	79	18	8,707	n.	36	s.	21	10	10	11	5.3	T.	0.0
Marquette	734	77	111	.....	29.95	− .06	47.6	+ 1.9	77	13	54	32	8	42	29	.....	.....	77	18	7,594	nw.	51	w.	22	3	10	18	.....	0.4	0.0
Port Huron	638	70	120	29.25	29.94	− .10	50.6	+ 1.1	74	17	59	29	13	42	30	46	42	80	14	8,798	sw.	38	nw.	11	10	12	9	4.9	T.	0.0
Saginaw	641	69	77	29.25	29.95	.....	50.4	.....	71	17	59	31	13	42	29	45	43	83	13	6,700	sw.	32	sw.	22	8	13	10	5.9	T.	0.0
Sault Sainte Marie	614	11	52	29.24	29.95	− .06	46.4	+ 3.0	66	13	53	27	21	40	31	42	39	80	12	6,084	se.	41	nw.	21	5	9	17	7.1	1.0	0.0
Chicago	823	140	310	29.07	29.96	− .08	54.8	+ 1.3	79	17	62	36	8	48	23	48	43	70	13	10,450	sw.	60	s.	17	14	10	7	4.2	T.	0.0
Green Bay	617	109	144	29.26	29.92	− .10	49.4	+ 2.3	69	1	56	30	8	42	27	44	41	81	8	8,960	sw.	42	w.	22	4	5	22	7.5	0.0	0.0
Milwaukee	681	125	139	29.20	29.94	− .09	51.8	+ 1.6	70	1	58	34	8	45	23	46	42	75	11	8,489	sw.	36	se.	25	11	5	15	5.6	0.0	0.0
Duluth	1,133	11	47	28.72	29.95	− .05	45.6	+ 0.4	74	15	54	29	8	38	33	40	38	83	10	10,554	nw.	53	w.	22	10	8	13	6.2	0.7	0.0
North Dakota.							47.8	+ 5.2											67	0.96	− 0.3										4.7		
Moorhead	940	50	58	28.93	29.96	− .04	47.8	+ 5.0	75	13	58	29	30	38	43	41	36	71	8	5,789	nw.	44	nw.	21	7	14	10	5.5	T.	0.0
Bismarck	1,674	8	57	28.21	30.01	+ .02	48.9	+ 4.8	85	4	62	24	12	36	46	40	32	62	6	6,470	nw.	49	w.	21	14	9	8	4.4	T.	0.0
Devils Lake	1,482	11	44	28.35	29.94	− .05	46.4	+ 5.9	79	4	57	24	7	35	38	39	34	73	11	6,899	nw.	44	w.	21	16	7	8	4.4	0.2	0.0
Ellendale	1,457	10	56	28.38	29.95	.....	47.8	.....	78	14	61	25	30	38	44	.....	.....	.....	6	10,121	nw.	53	nw.	10	12	10	9	4.9	0.0	0.0
Grand Forks	835	12	89	.....	.....	.....	46.8	.....	75	14	58	26	7	36	41	.....	.....	.....	8	.....	w.	51	w.	21	13	9	9	.....	3.0	0.0
Williston	1,878	41	48	27.98	29.98	.00	48.0	+ 5.1	77	20	61	25	31	35	40	39	32	62	3	0.10	− 0.7	3	5,441	w.	43	w.	21	13	12	6	4.5	0.0	0.0
Upper Mississippi Valley.							54.9	+ 2.1											71	1.94	− 0.5										4.6		
Minneapolis	918	102	208	28.94	29.92	.....	51.4	.....	75	21	60	33	7	43	33	.....	.....	.....	5	8,857	nw.	43	w.	22	10	12	9	5.5	T.	0.0
St. Paul	837	236	261	29.03	29.94	− .09	50.6	+ 2.5	73	21	60	30	8	42	34	.....	.....	.....	7	9,467	nw.	50	w.	22	13	9	9	4.7	T.	0.0
La Crosse	714	11	48	29.16	29.94	− .08	50.8	+ 0.9	74	16	61	30	12	41	31	.....	.....	.....	7	3,746	s.	30	ne.	29	10	8	13	5.8	0.0	0.0
Madison	974	70	78	28.91	29.96	− .07	50.8	+ 2.0	71	16	58	31	8	44	27	46	42	80	14	7,642	nw.	42	ne.	31	9	9	13	5.5	T.	0.0
Wausau	1,247	4	....	28.59	29.92	.....	48.0	.....	69	30	57	27	8	39	30	.....	.....	.....	11	.....	se.	.....	.....	.....	7	14	10	5.8	0.2	0.0
Charles City	1,015	10	49	28.87	29.96	− .06	51.2	+ 3.0	77	16	61	30	8	41	30	45	41	78	8	2.27	+ 0.2	8	5,244	nw.	27	ne.	29	9	12	10	5.7	0.0	0.0
Davenport	606	71	79	29.30	29.96	− .08	55.6	+ 3.0	79	16	65	32	8	46	25	48	43	71	10	2.38	0.0	5	5,866	sw.	29	ne.	6	12	9	10	4.7	T.	0.0
Des Moines	861	84	97	29.02	29.93	− .10	56.5	+ 4.0	85	16	67	32	12	46	39	47	40	63	8	1.51	− 1.2	8	5,893	sw.	30	nw.	19	13	13	5	4.2	0.0	0.0
Dubuque	698	81	96	29.22	29.97	− .07	52.9	+ 0.9	77	16	61	33	8	45	27	46	42	72	8	3.43	+ 0.8	8	5,002	nw.	24	nw.	19	9	11	11	5.4	T.	0.0
Keokuk	614	64	78	29.29	29.97	− .08	56.6	+ 2.1	84	24	67	31	8	46	30	49	44	68	10	2.56	+ 0.1	10	5,607	s.	34	nw.	19	12	11	8	4.5	0.0	0.0
Cairo	356	87	93	29.63	30.02	− .05	59.2	+ 0.1	82	24	70	38	8	49	32	51	45	69	5	0.82	− 1.8	5	5,670	se.	37	sw.	29	17	8	6	3.6	0.0	0.0
Peoria	609	11	45	29.31	29.97	− .08	55.6	+ 3.6	83	17	67	31	8	44	33	48	45	78	10	4,713	s.	25	nw.	19	18	10	3	3.5	0.0	0.0
Springfield, Ill	644	10	91	29.29	29.97	− .05	56.8	+ 2.2	81	17	67	34	8	46	30	48	44	73	7	1.61	− 1.0	7	6,480	s.	30	w.	19	17	9	5	3.6	0.0	0.0
Hannibal	534	74	109	29.41	29.98	− .07	57.9	+ 2.0	82	17	68	33	8	47	29	.....	.....	.....	10	2.16	+ 0.5	10	6,895	sw.	30	n.	7	20	5	6	3.2	0.0	0.0
St. Louis	567	265	303	29.38	29.98	− .08	59.6	+ 1.2	83	24	69	38	8	50	28	49	42	60	5	1.45	+ 1.0	5	10,518	s.	40	se.	28	23	3	5	2.6	0.0	0.0
Missouri Valley.							56.6	+ 3.9											61	1.41	− 0.5										3.5		
Columbia, Mo.	781	11	84	29.15	29.99	− .06	57.5	+ 2.7	82	17	69	32	12	46	34	.....	.....	.....	7	2.33	− 0.1	7	5,601	s.	32	nw.	19	21	5	5	3.1	0.0	0.0
Kansas City	963	161	181	28.92	29.96	− .08	60.1	+ 4.3	84	17	70	39	12	50	31	50	42	58	7	1.86	− 0.4	7	8,404	s.	44	nw.	19	16	10	5	3.3	0.0	0.0
St. Joseph	987	11	49	28.90	29.93	.....	59.0	.....	84	16	70	34	12	48	37	49	42	63	8	2.89	.....	8	6,192	sw.	36	nw.	19	19	6	6	2.9	0.0	0.0
Springfield, Mo.	1,324	98	104	28.60	30.00	− .05	58.8	+ 1.5	83	9	70	36	8	48	31	48	42	63	7	2.55	− 0.2	7	8,057	se.	36	s.	25	24	3	4	2.1	0.0	0.0
Iola	984	11	50	28.92	29.96	− .08	60.0	+ 3.1	86	17	73	31	12	47	39	.....	.....	.....	4	0.88	− 1.4	4	5,340	s.	26	n.	7	19	8	4	3.3	0.0	0.0
Topeka	987	92	107	.....	.....	.....	60.2	+ 3.9	89	9	73	34	12	48	41	.....	.....	.....	7	0.73	− 1.2	7	8,251	s.	38	nw.	19	16	8	7	3.6	0.0	0.0
Drexel	1,299	10	53	28.54	29.93	.....	50.3	.....	87	9	68	32	11	44	49	46	39	64	5	1.58	.....	5	8,250	s.	39	sw.	21	18	8	5	3.5	0.0	0.0
Lincoln	1,189	11	84	28.66	29.93	− .10	58.3	+ 5.0	90	9	71	32	12	46	47	48	42	64	5	0.93	− 0.9	5	8,591	s.	38	nw.	19	20	5	6	3.8	0.0	0.0
Omaha	1,105	115	122	28.77	29.94	− .09	58.6	+ 4.4	87	9	70	36	11	48	39	48	39	58	6	1.52	− 0.8	6	6,533	nw.	36	ne.	6	18	7	6	3.4	0.0	0.0
Valentine	2,598	47	54	27.27	30.00	− .01	51.8	+ 3.3	84	15	68	22	11	36	49	40	31	54	2	1.27	0.0	2	7,538	nw.	40	n.	25	18	11	2	2.9	0.0	0.0
Sioux City	1,135	94	164	28.74	29.96	− .07	55.2	+ 4.1	82	9	66	31	4	44	45	45	37	58	6	1.70	− 0.1	6	9,284	n.	52	nw.	10	13	11	7	4.5	0.0	0.0
Huron	1,306	59	74	28.58	30.00	− .01	51.1	+ 6.4	77	8	64	27	12	39	44	43	38	72	3	0.79	− 0.6	3	6,603	nw.	36	nw.	10	18	3	7	3.5	0.0	0.0
Pierre	1,572	70	75	28.31	29.98	− .03	53.0	+ 3.9	86	4	67	29	11	39	46	43	34	60	2	1.28	+ 0.5	2	6,363	nw.	40	nw.	10	17	7	7	3.8	0.0	0.0
Yankton	1,233	49	57	28.62	29.94	− .07	54.8	+ 4.3	84	21	67	33	11	42	42	.....	.....	.....	3	1.03	− 0.5	3	6,081	nw.	38	nw.	10	8	13	6	5.2	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1921*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with .01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*						*0–10*	*In.*	*In.*
Northern Slope.							**50.7**	**+ 6.1**										**52**	**0.38**	**− 0.6**										**3.6**		
Billings	3,140	5					51.8		90	4	72	18	7	32	56				T.		0						12	17	2		0.0	0.0
Havre	2,505	11	44	27.36	30.00	+ .02	50.6	+ 7.0	83	3	65	25	26	36	50	42	34	60	0.16	− 0.3	2	5,541	sw.	38	sw.	28	13	11	7	4.6	0.0	0.0
Helena	4,110	87	112	25.84	30.04	+ .01	51.4	+ 7.4	80	20	64	25	7	39	43	40	29	48	0.04	− 0.8	1	5,805	sw.	34	sw.	21	14	10	7	4.4	T.	0.0
Kalispell	2,973	48	56		30.04	+ .03	46.4	+ 3.9	72	4	58	28	7	35	39			60	1.15	0.0	8	3,590	nw.	24	w.	20	15	5	11	6.2	0.0	0.0
Miles City	2,371	26	48	27.48	30.05	+ .05	53.8	+ 7.3	83	20	68	26	26	39	45	43	37	64	0.06	− 0.7	1	4,351	se.	40	nw.	21	25	4	2	2.1	0.0	0.0
Rapid City	3,259	50	58	26.62	30.03	+ .02	53.3	+ 6.7	85	4	67	27	11	40	44	41	27	40	T.	− 1.1	0	7,175	w.	42	n.	6	15	13	3	3.7	0.0	0.0
Cheyenne	6,088	84	101	24.06	30.00	− .01	50.8	+ 5.5	78	4	65	22	7	37	40	39	28	46	0.06	− 0.7	2	8,881	w.	43	w.	8	17	10	4	3.4	T.	0.0
Lander	5,372	60	68	24.71	30.06	+ .02	50.4	+ 8.3	82	8	67	24	7	34	48	39	29	50	0.50	− 0.6	3	3,202	sw.	40	w.	27	20	10	1	2.8	0.0	0.0
Sheridan	3,790	10	47	26.14	30.05		49.2		84	4	68	18	7	30	54	37	25	47	0.24		4	3,566	s.	35	nw.	27	19	7	5	3.4	0.0	0.0
Yellowstone Park	6,200	11	48	23.96	30.09	+ .07	45.1	+ 3.6	75	4	60	20	7	30	46	35	24	51	0.56	− 0.6	5	5,244	s.	28	s.	15	17	9	5	3.3	5.0	T.
North Platte	2,821	11	51	27.09	30.02	.00	54.9	+ 4.9	90	21	73	27	11	37	53	41	32	55	0.92	− 0.2	2	5,778	nw.	38	n.	25	24	2	5	2.3	0.0	0.0
Middle Slope.							**59.4**	**+ 3.9**										**49**	**0.39**	**− 1.0**										**2.8**		
Denver	5,292	106	113	24.78	30.01	.00	56.0	+ 5.0	81	5	70	32	7	42	39	42	29	40	0.66	− 0.3	3	5,694	s.	40	n.	25	18	9	4	2.9	1.0	0.0
Pueblo	4,685	80	86	25.33	29.99	.00	56.5	+ 4.2	85	8	73	28	27	40	54	42	30	43	1.21	+ 0.5	5	4,325	nw.	33	nw.	25	13	16	2	3.8	T.	0.0
Concordia	1,392	50	58	28.49	29.96	− .07	59.4	+ 4.0	91	9	72	32	12	46	46	47	37	53	0.72	− 1.3	5	7,217	s.	38	n.	28	16	9	6	3.7	0.0	0.0
Dodge City	2,509	11	51	27.40	30.00	− .02	59.6	+ 4.9	92	9	75	34	27	44	45	46	36	51	0.23	− 1.2	3	7,581	nw.	40	ne.	7	25	5	1	1.7	0.0	0.0
Wichita	1,358	139	158	28.52	29.95	− .08	61.2	+ 2.4	92	9	73	40	8	49	40	50	42	57	0.52	− 1.8	5	10,654	s.	47	s.	25	19	9	3	2.8	0.0	0.0
Altus	1,410	5					65.5		93	6	81	35	8	50	47				0.02		1		se.				23	1	7		0.0	0.0
Broken Arrow	765	11	52	29.16	29.98		62.2		91	9	76	34	12	48	41				0.40		3	10,245	s.	44	s.	28	22	6	3	2.4	0.0	0.0
Muskogee	652	4					64.0		92	9	80	32	8	48	45				0.47		6		w.				21	6	4		0.0	0.0
Oklahoma City	1,214	10	47	28.71	29.99	− .04	64.0	+ 2.7	90	6	77	37	8	51	39	50	40	52	0.18	− 1.6	3	7,590	s.	46	n.	7	21	8	2	1.7	0.0	0.0
Southern Slope.							**66.4**	**+ 3.9**										**47**	**0.10**	**− 1.8**										**1.8**		
Abilene	1,738	10	52	28.20	29.99	− .02	68.2	+ 4.0	96	10	82	34	8	54	41	52	39	44	0.01	− 2.3	1	7,347	s.	34	n.	7	23	7	1	1.7	0.0	0.0
Amarillo	3,676	10	49	26.28	29.98	− .02	62.8	+ 6.7	91	9	78	38	27	48	45	49	40	54	0.28	− 1.4	4	8,756	sw.	38	n.	7	26	5	0	2.5	0.0	0.0
Del Rio	944	64	71	29.02	29.99	+ .01	71.8	+ 1.9	94	10	84	43	29	60	38				0.13	− 1.9	2	6,638	se.	35	nw.	28	26	3	2	1.4	0.0	0.0
Roswell	3,506	75	85	26.39	29.98	+ .02	62.6	+ 3.1	90	10	80	32	27	45	49	47	33	42	T.	− 1.5	0	5,290	s.	39	w.	24	26	3	2	1.5	0.0	0.0
Southern Plateau.							**65.8**	**+ 3.0**										**48**	**0.33**	**− 0.2**										**1.7**		
El Paso	3,762	110	133	26.22	29.94	+ .02	66.5	+ 4.1	88	10	80	36	29	53	35	50	37	39	0.11	− 0.8	3	6,679	e.	40	ne.	14	28	3	0	0.9	0.0	0.0
Santa Fe	7,013	57	66	23.33	30.00	+ .04	53.0	+ 3.0	78	19	65	28	28	41	33	41	32	54	0.98	− 0.1	4	5,395	e.	30	w.	27	18	11	2	2.7	T.	0.0
Flagstaff	6,908	8	57																														
Phoenix	1,108	76	81	28.74	29.88	.00	73.8	+ 3.6	100	20	90	44	26	58	43	58	50	51	0.11	− 0.2	2	3,308	e.	30	w.	24	25	4	2	1.8	0.0	0.0
Yuma	141	9	54	29.73	29.88	+ .01	75.2	+ 2.8	101	19	90	46	25	61	38	62	55	59	0.04	− 0.2	1	2,555	w.	20	nw.	23	28	1	2	1.1	0.0	0.0
Independence	3,957	9	41	26.01	30.03	+ .08	60.7	+ 1.4	85	19	76	32	26	46	41	45	29	37	0.43	+ 0.1	4	3,136	se.	39	se.	22	23	6	2	2.1	0.0	0.0
Middle Plateau.							**55.4**	**+ 4.6**										**44**	**0.77**	**0.0**										**3.1**		
Reno	4,532	74	81	25.52	30.01	+ .02	54.6	+ 4.9	85	19	72	25	24	38	47	41	28	43	0.39	0.0	3	3,953	w.	41	w.	26	21	7	3	2.8	0.3	0.0
Tonopah	6,090	12	20	24.14	30.00		57.3		81	18	67	26	25	47	26	44	29	37	0.28	− 0.6	4	5,218	se.	26	se.	5	17	13	1	3.2	2.0	0.0
Winnemucca	4,344	18	56	25.68	30.07	+ .02	51.9	+ 3.3	84	4	72	19	24	32	52	39	26	44	0.05	− 0.5	2	4,766	ne.	27	sw.	26	18	4	9	3.4	0.0	0.0
Modena	5,479	10	43	24.67	30.00	+ .04	54.0	+ 3.9	85	18	70	25	28	38	47	41	29	46	1.97	+ 1.2	4	6,371	w.	39	s.	22	23	3	5	2.6	0.0	0.0
Salt Lake City	4,360	163	203	25.68	30.04	+ .03	58.6	+ 6.4	83	20	69	35	27	48	30	46	35	46	1.29	− 0.1	4	4,689	nw.	40	nw.	26	20	5	6	3.1	T.	0.0
Grand Junction	4,602	60	68	25.45	30.03	+ .04	58.0	+ 4.7	82	19	72	27	28	44	39	45	35	50	0.66	− 0.2	4	3,634	se.	26	se.	6	19	7	5	3.3	T.	0.0
Northern Plateau.							**53.7**	**+ 4.9**										**57**	**0.66**	**− 0.6**										**4.1**		
Baker	3,471	48	53	26.50	30.10	+ .02	49.8	+ 4.3	82	3	64	25	23	36	44	41	33	58	0.27	− 0.6	5	4,812	se.	22	s.	25	16	5	10	3.9	0.0	0.0
Boise	2,739	78	86	27.21	30.07	+ .01	55.6	+ 5.3	82	6	69	33	21	42	38	47	40	59	0.16	− 1.1	3	2,805	se.	26	nw.	20	17	10	4	3.2	0.0	0.0
Lewiston	757	40	48	29.26	30.07	.00	55.4	+ 3.6	82	4	69	30	23	42	42				0.81	− 0.4	9	1,571	e.	24	w.	20	14	5	12	4.6	0.0	0.0
Pocatello	4,477	60	68	25.54	30.06	+ .02	53.4	+ 5.4	81	4	68	31	7	38	41	40	29	46	0.56	− 0.4	4	5,577	se.	36	sw.	27	19	6	6	3.3	0.0	0.0
Spokane	1,929	101	110	28.01	30.06	.00	50.8	+ 7.3	77	4	63	30	1	39	40	44	38	64	0.94	− 0.6	8	3,720	sw.	31	sw.	28	12	7	12	4.9	0.0	0.0
Walla Walla	901	57	65	28.97	30.04	− .03	57.0	+ 3.3	81	4	68	35	23	46	32	48	40	57	1.20	− 0.3	9	2,776	s.	24	w.	15	15	5	11	4.5	0.0	0.0
North Pacific Coast Region.							**54.1**	**+ 2.4**										**83**	**5.58**	**+ 1.7**										**6.2**		
North Head	211	11	56	29.77	30.00	− .05	53.6	+ 0.7	74	2	58	45	23	49	20	52	50	91	6.18	+ 2.3	17	14,301	s.	84	s.	25	8	8	15	6.0	0.0	0.0
Port Angeles	29	8	53	29.99	30.02		49.6		68	10	57	33	23	43	23				3.92	+ 1.4	14	3,468	s.	34	sw.	17	11	5	15	5.9	0.0	0.0
Seattle	125	215	250	29.91	30.04	− .01	53.2	+ 2.4	69	7	59	36	23	47	23	51	49	87	3.91	+ 1.0	15	6,596	se.	38	s.	15	6	7	18	7.2	0.0	0.0
Tacoma	213	113	120	29.83	30.06	+ .02	52.3	+ 1.7	70	10	59	33	23	45	25				2.77	− 0.6	14	4,324	n.	29	ne.	22	6	7	18	7.3	0.0	0.0
Tatoosh Island	86	7	57	29.87	29.96	− .05	51.4	+ 1.5	61	10	55	44	23	47	14	50	48	90	17.36	+ 9.4	19	13,216	s.	72	s.	28	6	7	18	6.9	0.0	0.0
Yakima	1,071	4																															
Medford	1,425	4																															
Portland, Oreg	153	68	106	29.87	30.03	− .03	57.0	+ 3.7	79	2	66	42	23	49	30	52	48	76	2.78	− 0.9	12	4,191	nw.	26	sw.	27	10	4	17	5.9	0.0	0.0
Roseburg	510	9	57	29.49	30.04	− .04	57.1	+ 4.3	85	8	69	37	1	46	44	51	46	72	2.13	− 0.5	9	1,902	nw.	21	sw.	26	12	11	8	4.3	0.0	0.0
Middle Pacific Coast Region.							**60.5**	**+ 1.7**										**72**	**0.75**	**− 0.7**										**4.4**		
Eureka	62	73	89	30.00	30.07	+ .01	54.5	+ 1.4	71	17	60	42	23	49	19	52	50	88	1.59	− 1.1	7	3,724	se.	35	se.	25	5	7	19	7.2	0.0	0.0
Mount Tamalpais	2,375	11	18																														
Point Reyes Light	490	7	18	29.48	30.00		56.3	+ 1.6	76	19	61	46	23	52	23				1.18		5	11,413	nw.	52	nw.	21	9	5	17	6.2	0.0	0.0
Red Bluff	332	50	56	29.63	29.98	− .05	65.4	+ 1.6	97	7	79	38	27	52	42	56	48	57	0.65	− 0.9	3	3,183	se.	24	se.	26	21	5	5	2.9	0.0	0.0
Sacramento	69	106	117	29.92	29.99	.00	64.0	+ 1.8	88	20	77	40	27	51	35	56	50	62	0.80	− 0.2	3	4,211	s.	27	s.	21	22	8	1	1.8	0.0	0.0
San Francisco	155	208	243	29.85	30.02	+ .01	61.5	+ 3.1	85	19	68	50	27	55	25	56	53	80	0.52	− 0.8	4	5,499	w.	34	w.	21	16	7	8	4.6	0.0	0.0
San Jose	141	12	110	29.89	30.04		61.2	+ 0.9	90	19	74	39	27	49	42				0.21	− 0.7	5	3,572	nw.	23	nw.	21	15	11	5	4.0	0.0	0.0
South Pacific Coast Region.							**65.5**	**+ 2.6**										**67**	**0.36**	**− 0.5**										**3.6**		
Fresno	327	89	98	29.63	29.99	+ .03	66.6	+ 1.9	92	19	80	42	25	53	37	55	45	53	T.	− 0.7	0	4,131	nw.	28	nw.	27	20	9	2	2.4	0.0	0.0
Los Angeles	338	159	191	29.61	29.98	+ .03	66.7	+ 2.1	99	19	76	48	24	58	36	58	52	72	0.59	− 0.2	3	3,494	sw.	17	s.	22	16	6	9	3.7	0.0	0.0
San Diego	87	62	70	29.86	29.95	.00	64.6	+ 1.6	87	20	70	50	25	59	28	59	56	79	0.67	+ 0.2	4	4,112	nw.	24	nw.	24	12	8	11	4.9	0.0	0.0
San Luis Obispo	201	32	40	29.79	30.01	+ .02	64.2	+ 5.0	103	18	77	38	24	52	45	53	46	65	0.16	− 1.2	3	3,128	nw.	30	ne.	27	17	11	3	3.6	0.0	0.0
West Indies.																																	
San Juan, P. R	82	8	54	29.85	29.93		79.5		89	20	85	72	5	74	15				6.24		18	6,980	e.	33	e.	15	8	15	8	5.4	0.0	0.0
Panama Canal.																																	
Balboa Heights	118	7	97																														
Colon	25	5	71																														
Alaska.																																	
Juneau	80	11	49																														

TABLE 2.—*Data furnished by the Canadian Meteorological Service, October, 1921.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	*°F*	*°F*	*°F*	*°F*	*°F*	*°F*	*In.*	*In.*	*In.*
St. Johns, N. F.	125	29.60	29.74	−0.17	46.0	+0.6	52.2	39.8	75	25	3.81	−1.54	1.0
Sydney, C. B. I.	48	29.84	29.88	− .08	48.8	+2.3	55.4	42.2	68	31	2.92	−1.77	T.
Halifax, N. S.	88	29.82	29.93	− .07	48.9	+1.7	57.5	40.2	70	22	2.93	−2.62	0.0
Yarmouth, N. S.	65	29.84	29.91	− .11	50.6	+3.0	57.3	43.6	67	26	1.99	−2.71	0.0
Charlottetown, P. E. I.	38												
Chatham, N. B.	28	29.85	29.88	− .08	46.5	+3.5	55.8	37.2	72	23	2.36	−1.50	1.0
Father Point, Que.	20	29.84	29.86	− .09	38.7	−1.1	44.7	32.7	63	20	6.64	+3.74	0.0
Quebec, Que.	296	29.57	29.89	− .11	43.8	+1.4	50.3	37.3	61	26	4.05	+0.90	T.
Montreal, Que.	187	29.71	29.92	− .09	46.9	+2.1	53.6	40.2	64	30	4.68	+1.55	0.1
Stonecliffe, Ont.	489	29.31	29.94	− .07	44.1	+1.3	52.5	35.7	70	26	2.05	−0.38	T.
Ottawa, Ont.	236	29.66	29.92	− .09	46.2	+2.4	55.6	36.9	73	24	4.74	+2.19	0.0
Kingston, Ont.	285	29.62	29.93	− .10	50.3	+3.3	57.4	43.1	67	30	4.04	+1.31	0.0
Toronto, Ont.	379	29.54	29.95	− .09	50.3	+3.7	58.9	41.8	72	33	4.46	+2.10	0.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.59	29.91	− .07	39.2	+2.1	49.2	29.1	64	13	0.45	−1.90	0.4
Port Stanley, Ont.	592	29.32	29.96	− .09	49.5	+1.7	57.6	41.5	66	31	3.06	+1.08	0.2
Southampton, Ont.	656	29.21			49.6	+3.5	56.2	43.0	67	29	3.30	+0.13	0.0
Parry Sound, Ont.	688	29.20	29.90	− .11	46.4	+2.5	54.6	38.2	65	27	4.85	+0.93	T.
Port Arthur, Ont.	644	29.21	29.92	− .06	43.8	+3.9	51.3	36.4	66	27	1.53	−1.03	0.0
Winnepeg, Man.	760	29.07	29.90	− .08	45.3	+6.2	54.8	35.7	76	26	0.93	−0.77	0.0
Minnedosa, Man.	1,690	28.10	29.93	− .04	44.0	+6.2	54.4	33.5	72	24	0.59	−0.61	1.5
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.66	29.91	− .06	44.2	+4.8	55.2	33.2	73	20	1.43	+0.33	T.
Medicine Hat, Alb.	2,144	27.61	29.89	− .08	51.3	+6.5	65.2	37.5	81	28	0.42	−0.16	0.0
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.40	30.03	+ .06	47.5	+5.4	60.4	34.7	80	24	0.78	−0.10	0.6
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.37	29.98	+ .03	41.8	+2.5	51.9	31.7	65	15	0.80	−0.22	1.9
Edmonton, Alb.	2,150	27.56	29.86	− .07	44.8	+3.7	58.6	31.0	81	18	0.08	−0.62	0.0
Prince Albert, Sask.	1,450	28.33	29.91	− .06	43.2	+6.1	54.0	32.4	76	24	0.30	−0.53	0.0
Battleford, Sask.	1,592	28.15	29.90	− .07	45.0	+5.4	57.6	32.5	78	23	0.35	−0.10	0.0
Kamloops, B. C.	1,262	28.76	29.99	+ .03	49.3	+2.3	59.4	39.2	72	21	0.09	−0.52	0.0
Victoria, B. C.	230	29.74	29.99	− .02	51.1	+1.9	56.6	45.6	73	39	4.74	+2.37	0.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.89	30.05	− .03	73.7	+0.7	78.8	68.6	84	63	5.05	−1.66	0.0
LATE REPORTS, SEPTEMBER, 1921.													
Kamloops, B. C.	1,262	28.71	29.92	+ .05	54.9	−2.5	65.0	44.7	76	33	0.49	−0.36	0.0
Barkerville, B. C.	4,180	25.61	29.91	− .07	41.3	−5.4	50.1	32.4	60	24	6.80	+3.89	0.0
Hamilton, Ber.	151	29.91	30.07	.00	77.9	+0.5	84.0	71.7	90	65	4.09	+2.42	0.0
Halifax, N. S.	88	29.89	29.99	− .05	58.8	+1.2	68.5	49.1	84	33	1.83	−1.88	0.0
Banff, Alb.	4,521	25.33	29.90	− .03	43.2	−2.6	53.0	33.4	68	23	2.16	+0.49	4.1
Medicine Hat, Alb.	2,144	27.57	29.84	− .08	53.6	−1.4	65.6	41.7	79	29	1.82	+0.64	5.2
Edmonton, Alb.	2,150	27.55	29.84	− .06	47.8	−1.5	61.0	34.7	74	19	0.66	−0.67	0.0
Winnepeg, Man.	760												
Minnedosa, Man.	1,690												

SEISMOLOGICAL REPORTS FOR OCTOBER, 1921.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, Dec. 3, 1921.]

TABLE 1.—*Noninstrumental earthquake reports, October, 1921.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		COLORADO.								
1921.	*H. m.*		° ′	° ′			*M. s.*			
15	2 55	Eads	38 30	102 50		1	2-3	Rumbling	Felt by several	C. H. Tracy.
		ILLINOIS.								
9	7 50	Waterloo	38 20	90 10	3	5	2	do	do	W. E. Eilbraith.
	11 50	do	38 20	90 10	3	3	3	do	do	Do.
		MAINE.								
16	13 00	Eastport	45 00	67 00	4			do	Felt by many	Percy Gee.
		UTAH.								
27		Joseph	38 40	112 00	5			do	Shocks on Sept. 29, 30, Oct. 1, 4	G. A. Warenski.
	14 15	Richfield	38 45	112 00	8	2	5	Faint	Felt by many	G. F. Holmstead.

TABLE 2.—*Instrumental seismological reports, October, 1921.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols, see REVIEW for January, 1921, p. 47.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*								
1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 15	.....	e_E	5 23 46	.....	.....	.....	.....	Not recorded on N.
		S_E	5 28 24	22	.....	.....	.....	
		L_E	5 40 51	25	.....	.....	.....	
		M_E	5 44 28	20	10	.....	.....	
		C_E	5 58 ..	.....	.....	.....	.....	
		F_E	6 09 ..	.....	.....	.....	.....	
20	.....	P_E	6 13 55	3	.....	.....	.....	Not recorded on N.
		S_E	6 22 08	10	.....	.....	.....	Actual maximum, 20μ, at 6:23:39.
		L_E	6 31 17	22	.....	.....	.....	No definite L.
		F_E	6 51 ..	.....	.....	.....	.....	
DISTRICT OF COLUMBIA. *Georgetown University, Washington.*								
1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 15	.....	eP_E?	5 20 27	.....	.....	.....	.....	Very heavy micros; P doubtful.
		ePN?	5 20 30	.....	.....	.....	.....	
		S	5 28 27	.....	.....	.....	.....	
		eL_E	5 35 12	.....	.....	.....	.....	
		eL_N	5 35 36	.....	.....	.....	.....	
		L_E	5 59 07	32	.....	.....	.....	
		L_N	5 59 27	27	.....	.....	.....	
		L_E	6 06 33	20	.....	.....	.....	
		F	7 20 —	.....	.....	.....	.....	
20	.....	eP_E	6 13 13	.....	.....	.....	.....	No distinct micros.
		iP_N	6 13 13	.....	.....	.....	.....	
		i_N	6 13 44	.....	.....	.....	.....	
		iS_E	6 21 10	.....	.....	.....	.....	
		iS_N	6 21 09	.....	.....	.....	.....	
		eL_E	6 28 30	.....	.....	.....	.....	
		eL_N	6 28 30	.....	.....	.....	.....	
		L_E	6 41 26	21	.....	.....	.....	
		F	7 ca.	.....	.....	.....	.....	
			VERTICAL.					
		iP_E	*6 13 07*	.....	.....	.....	.....	
		i_E	*6 13 40*	.....	.....	.....	.....	
		S_E	*6 21 05*	.....	.....	.....	.....	
		eL_E?	*6 27 42*	.....	.....	.....	.....	
		L_E	*6 35 35*	*19*	.....	.....	.....	
		F	*6 57* ..	.....	.....	.....	.....	
25	.....	L_E	16 02 40	20	.....	.....	.....	Very heavy micros.
		F	16 12 ..	.....	.....	.....	.....	
DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*								
1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 1	.....	e	21 19 ..	.....	.....	.....	.....	
		eL	21 24 ..	18	.....	.....	.....	
		F	21 28 ..	.....	.....	.....	.....	
15	.....	eL	5 50 ..	.....	.....	.....	.....	
		F	6 15 *ca.*	.....	.....	.....	.....	
20	.....	P	6 13 08	.....	.....	.....	6,450	
		S	6 21 08	.....	.....	.....	.....	
		eL	6 38 30	18	.....	.....	.....	
		F	6 55 ..	.....	.....	.....	.....	
ILLINOIS. *U. S. Weather Bureau, Chicago.*								
1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 5	.....	e	2 00 05	.....	.....	.....	.....	
		eL	2 13 40	18	.....	.....	.....	
		F	2 40 *ca*	.....	.....	.....	.....	
9	.....	eL	1 36 ..	.....	.....	.....	.....	
		F	2 15 *ca*	.....	.....	.....	.....	
14	.....	eL	17 46 45	.....	.....	.....	.....	
		F	18 10 *ca*	.....	.....	.....	.....	
15	.....	P	5 17 30	.....	.....	.....	8,200	
		S	5 27 00	.....	.....	.....	.....	
		SR1	5 33 15	.....	.....	.....	.....	
		eL	5 50 ..	.....	.....	.....	.....	
		L	5 53 ..	22	.....	.....	.....	
		L	6 05 ..	16	.....	.....	.....	
		F	8 *ca*	.....	.....	.....	.....	

TABLE 2.—*Instrumental seismological reports, October, 1921*—Contd.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. AE	Amplitude. AN	Distance.	Remarks.
ILLINOIS. *U. S. Weather Bureau, Chicago*—Continued.								
1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 18	.....	eL	1 23 00	18	.....	.....	.....	
		F	2 15 *ca*	.....	.....	.....	.....	
18	.....	eL	12 52 ..	18	.....	.....	.....	
		F	15 30 *ca*	.....	.....	.....	.....	
20	.....	P	6 13 06	.....	.....	.....	7,000	Jumbled record.
		S	6 21 32	.....	.....	.....	.....	
		L?	6 32 00	.....	.....	.....	.....	
		F	8 30 ..	.....	.....	.....	.....	
25	.....	P	16 00 20	.....	.....	.....	.....	
		L	16 04 40	18	.....	.....	.....	
		F	16 30 *ca*	.....	.....	.....	.....	
MISSOURI. *St. Louis University, St. Louis.*								
1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 9–10	.....	.....	.....	.....	.....	.....	.....	Intermittent micros.
10	.....	L_N	15 52 42	6	.....	*2,000	.....	
		L_E	15 52 42	3	*1,000	.....	.....	
15	.....	e	5 21 42	.....	.....	.....	.....	No record on NS.
		e	5 27 ..	.....	.....	.....	.....	
		eL_E	5 55 03	.....	.....	.....	.....	
		M_E	5 56 30	24	*6,000	.....	.....	
		F	6 11 ..	.....	.....	.....	.....	
20	.....	iS_E?	6 13 26	.....	.....	.....	.....	
		iS_N?	6 13 26	.....	.....	.....	.....	
		M_E	6 21 32	6	*5,000	.....	.....	
		M_E	6 22 26	5	*4,000	.....	.....	
		M_N	6 21 35	6	.....	*4,000	.....	
		M_N	6 22 36	6	.....	*4,000	.....	
		F	6 46 ..	.....	.....	.....	.....	

* Trace amplitude.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 15	.....	$PR1_E$	5 25 45	.....	.....	.....	.....	
		S_E	5 32 11	.....	.....	.....	.....	
		L_N	5 47 29	35	.....	.....	.....	
		M_E	6 10 15	24	10	.....	.....	
		M_N	6 10 49	23	.....	10	.....	
		C_E	6 15 ..	.....	.....	.....	.....	
		C_N	6 13 ..	.....	.....	.....	.....	
		F_E	6 30 ..	16	.....	.....	.....	
		F_N	6 33 ..	20	.....	.....	.....	
20	.....	P_N	6 13 17	3	.....	.....	.....	Record on E very faint.
		S_E	6 21 06	.....	.....	.....	.....	
		S_N	6 21 15	11	.....	.....	.....	
		L_E	6 28 36	.....	.....	.....	.....	
		L_N	6 28 46	22	.....	.....	.....	
		M_N	6 41 42	.....	.....	20	.....	
		C_N	6 43 ..	.....	.....	.....	.....	
		F_E	6 50 ..	.....	.....	.....	.....	

NEW YORK. *Cornell University, Ithaca.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 15	.....	L	5 51 ..	20	.....	.....	.....	
		L	5 58 ..	22	.....	.....	.....	
		F	6 20 ..	.....	.....	.....	.....	
20	.....	eP	6 13 35	.....	.....	.....	.....	
		i	6 14 05	3	.....	.....	.....	
		e	6 18 30	5	.....	.....	.....	
		e	6 21 53	3	.....	.....	.....	
		i	6 22 46	6	.....	.....	.....	
		L	6 29 30	20	.....	.....	.....	
		F	7 08 ..	.....	.....	.....	.....	

NEW YORK. *Fordham University, New York.*

1921.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Oct. 15	.....	.....	6 56 30	.....	.....	.....	.....	Several groups of regular waves of short amplitude.

TABLE 2.—*Instrumental seismological reports, October, 1921*—Contd.

CANAL ZONE. *Panama Canal, Balboa Heights.*

1921.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 7	.....	S.....	10 46 55	.....	.....	.....	.....	Probably local.
		M_E....	10 47 03	.....	*200	.....	.....	
		M_N....	10 47 05	.....	.....	*500	.....	
		F.....	10 48 30	.....	.....	.....	.....	
17	.....	P_E.....	11 36 22	.....	.....	.....	.....	Probably to west; felt throughout zone.
		P_N....	11 36 18	.....	.....	.....	110 *ca.*	
		S_E.....	11 36 34	.....	.....	.....	.....	
		S_N....	11 36 31	.....	.....	.....	.....	
		M.....	11 36 38	.....	*13000	*27000	.....	
		F_E.....	11 40 30	.....	.....	.....	.....	
		F_N.....	11 40 40	.....	.....	.....	.....	
20	.....	P_E.....	6 09 20	.....	.....	.....	3,200	To the south; cable reports indicate Iquique, Chile.
		P_N....	6 09 18	.....	.....	.....	.....	
		S_E.....	6 14 20	.....	.....	.....	.....	
		S_N....	6 14 18	.....	.....	.....	.....	
		L.....	6 18 00	.....	.....	.....	.....	
		M_E....	6 15 18	.....	*2000	.....	.....	
		M_N....	6 15 12	.....	.....	*3,000	.....	
		F_E.....	6 33 00	.....	.....	.....	.....	
		F_N.....	6 35 00	.....	.....	.....	.....	
25	.....	P_E.....	15 46 28	.....	.....	.....	435 *ca.*	Probably to the west.
		P_N....	15 46 27	.....	.....	.....	.....	
		S_E.....	15 47 14	.....	.....	.....	.....	
		S_N....	15 47 11	.....	.....	.....	.....	
		L_E.....	15 47 46	.....	.....	.....	.....	
		L_N....	15 47 43	.....	.....	.....	.....	
		M_E....	15 48 17	.....	*15500	.....	.....	
		M_N....	15 47 51	.....	.....	*20000	.....	
		F_E.....	16 05 00	.....	.....	.....	.....	
		F_N.....	16 08 30	.....	.....	.....	.....	
26	.....	P_E.....	17 00 44	.....	.....	.....	435 *ca.*	Do.
		P_N....	17 00 42	.....	.....	.....	.....	
		S_E.....	17 01 31	.....	.....	.....	.....	
		S_N....	17 01 28	.....	.....	.....	.....	
		L_E.....	17 01 59	.....	.....	.....	.....	
		L_N....	17 01 54	.....	.....	.....	.....	
		M_E....	17 01 46	.....	*1,000	.....	.....	
		M_N....	17 01 44	.....	.....	*1,000	.....	
		F_E.....	17 08 00	.....	.....	.....	.....	
		F_N.....	17 07 00	.....	.....	.....	.....	

* Trace amplitude.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1921.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 20	.....	P_N....	6 10 38	6	.....	.....	.....	
		S.....	6 16 09	12	.....	.....	.....	
		L.....	6 19 18	21	.....	.....	.....	
		M_E....	6 19 33	18	50	.....	.....	
		M_N....	6 19 31	12	.....	10	.....	
		C_E.....	6 20 43	.....	.....	.....	.....	
		F_E.....	6 36 ..	.....	.....	.....	.....	
		F_N.....	6 30 ..	.....	.....	.....	.....	
30	.....	P_E.....	9 49 13	1	.....	.....	.....	Local.
		P_N....	9 49 20	1	.....	.....	.....	
		L_E.....	9 49 33	4	20	.....	.....	
		M_E....	9 49 39	4	.....	20	.....	
		F_E.....	9 50 34	.....	.....	.....	.....	
		F_N.....	9 51 13	.....	.....	.....	.....	

CANADA. *Dominion Observatory, Ottawa.*

1921.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 1	.....	eL_E...	21 20 ..	50	.....	.....	.....	NS lost in micros; quakes reported in Utah.
		L.....	21 25 ..	25	.....	.....	.....	
		F.....	21 30 ..	.....	.....	.....	.....	
15	.....	$eS?_E$...	5 28 00	.....	.....	.....	.....	Probably 11,000 or 12,000 km. distant.
		$eSR1?_E$	5 34 47	.....	.....	.....	.....	
		e_E.....	5 45 ..	.....	.....	.....	.....	
		eL_E...	5 55 ..	26	.....	.....	.....	
		L_{NV}...	5 59 ..	22	.....	.....	.....	
		L_{NV}...	6 03 ..	19	.....	.....	.....	
		L_{NV}...	6 31 ..	16	.....	.....	.....	
		$eLR1?_E$	6 55 ..	(22)	.....	.....	.....	
		L_E.....	7 08 ..	18	.....	.....	.....	
		L_E.....	7 23 ..	18	.....	.....	.....	
		F.....	7 35 ..	.....	.....	.....	.....	
20	.....	O?.....	6 03 15	.....	.....	.....	7,140	Very irregular and uncertain record; waves not plainly recorded, but show on all three components.
		P?.....	6 13 50	.....	.....	.....	.....	
		i.....	6 14 21	.....	.....	.....	.....	
		$PR1?_{EV}$	6 16 42	.....	.....	.....	.....	
		S?.....	6 22 26	.....	.....	.....	.....	
		i.....	6 23 22	.....	.....	.....	.....	
		i.....	6 24 29	.....	.....	.....	.....	
		SR1?.	6 27 28	.....	.....	.....	.....	
		SR2?..	6 29 50	.....	.....	.....	.....	
		eL.....	6 33 ..	.....	.....	.....	.....	
		L_E.....	6 37 ..	.....	.....	.....	.....	
		L_E.....	7 09 ..	.....	.....	.....	.....	
		F.....	7 20 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental seismological reports, October, 1921*—Contd.

CANADA. *Dominion Meteorological Service, Toronto.*

1921.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 1	.....	L.....	17 18 00	.....	.....	.....	.....	Doubtful as to being seismic; some characteristics strikingly seismic.
		eL.....	17 19 48	.....	.....	.....	.....	
		M.....	17 23 00	.....	$500	.....	.....	
		F.....	17 29 24	.....	.....	.....	.....	
1	.....	L.....	21 22 42	.....	.....	.....	.....	Utah.
		L.....	21 25 30	.....	*100	.....	.....	
		L.....	21 29 12	.....	.....	.....	.....	
9	.....	L.....	1 45 12	.....	.....	.....	.....	Continuous minute vibrations; micros going on.
		F.....	1 53 36	.....	*200	.....	.....	
9	.....	L.....	7 33 30	.....	*50	.....	.....	
10	.....	L.....	2 38 24	.....	.....	.....	.....	
		L.....	3 08 00	.....	*200	.....	.....	
		F.....	.....	.....	.....	.....	.....	Micros.
14	.....	L.....	17 47 24	.....	.....	.....	.....	
		M.....	17 55 36	.....	*200	.....	.....	
		F.....	18 21 18	.....	.....	.....	.....	
15	.....	iP.....	5 19 30	.....	.....	.....	.....	
		S.....	5 28 12	.....	.....	.....	7,200	
		SR1...	5 34 42	.....	.....	.....	.....	
		i.....	5 48 18	.....	.....	.....	.....	
		L.....	6 01 48	.....	.....	.....	.....	
		eL.....	6 03 54	.....	.....	.....	.....	
		M.....	6 12 00	.....	*2,000	.....	.....	
		eL.....	6 15 06	.....	.....	.....	.....	
		iL.....	6 16 06	.....	.....	.....	.....	
		iL.....	6 25 42	.....	.....	.....	.....	
		eL.....	6 31 18	.....	.....	.....	.....	
		iL.....	7 07 54	.....	.....	.....	.....	
		eL.....	7 18 00	.....	.....	.....	.....	
		eL.....	7 32 06	.....	.....	.....	.....	
		F.....	7 46 12	.....	.....	.....	.....	
20	.....	iS.....	6 22 42	.....	.....	.....	.....	P not recorded; S very abrupt.
		SR1....	6 26 36	.....	.....	.....	.....	
		SR2....	6 30 48	.....	.....	.....	.....	
		iL.....	6 32 30	.....	.....	.....	.....	
		eL.....	6 36 00	.....	.....	.....	.....	
		M.....	6 39 12	.....	.....	.....	.....	
		F.....	7 16 42	.....	*1,000	.....	.....	
20	.....	eL.....	11 50 42	.....	.....	.....	.....	
		M.....	11 52 42	.....	*100	.....	.....	
		F.....	12 10 30	.....	.....	.....	.....	
25	.....	eL.....	16 04 48	.....	.....	.....	.....	Continuous vibration up to 16h 43*m* 18*s*; quick period.
		M.....	16 07 00	.....	*400	.....	.....	
		F.....	16 27 36	.....	.....	.....	.....	

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

1921.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 5	.....	L.....	?1 54 58	.....	.....	.....	.....	
		M.....	2 01 52	.....	*250	.....	.....	
		F.....	2 11 42	.....	.....	.....	.....	
9	.....	S.....	?1 22 06	.....	.....	.....	.....	
		L.....	1 26 31	.....	.....	.....	.....	
		M.....	1 36 51	.....	*200	.....	.....	
		F.....	1 51 36	.....	.....	.....	.....	
9	.....	L.....	7 26 32	.....	.....	.....	.....	
		M.....	7 30 28	.....	*300	.....	.....	
		F.....	7 36 22	.....	.....	.....	.....	
10	.....	S.....	2 18 42	.....	.....	.....	.....	
		L.....	2 29 31	.....	.....	.....	.....	
		M.....	2 56 04	.....	*500	.....	.....	
		F.....	?3 38 22	.....	.....	.....	.....	
14	.....	S.....	17 30 46?	.....	.....	.....	.....	
		L.....	17 35 12	.....	.....	.....	.....	
		M.....	17 45 31	.....	*250	.....	.....	
		F.....	18 18 29	.....	.....	.....	.....	
15	.....	P.....	5 10 38	.....	.....	.....	2,760	
		S.....	5 15 03	.....	.....	.....	.....	
		L.....	5 20 57	.....	.....	.....	.....	
		M.....	5 49 28	.....	*600	.....	.....	
		F.....	7 20 57	.....	.....	.....	.....	
		M.....	VERTICAL *?5 48 00*	.....	*?*	.....	.....	P, S, & L masked by micros.
20	.....	P.....	6 14 29	.....	.....	.....	.....	
		S.....	6 17 56	.....	.....	.....	.....	
		iL.....	6 23 19	.....	.....	.....	.....	
		iL.....	6 24 19	.....	.....	.....	.....	
		M.....	6 27 16	.....	*600	.....	.....	
		F.....	7 40 43	.....	.....	.....	.....	
20	.....	L.....	11 14 29	.....	.....	.....	.....	
		M.....	11 22 51	.....	*250	.....	.....	
		F.....	11 28 45	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, October, 1921*—Contd.

CANADA. *Dominion Meteorological Service, Victoria*—Continued.

1921.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 25	.....	L.....	1 23 11	.....	.....	.....	.....	
		M.....	1 36 27	.....	*200	.....	.....	
		F.....	1 43 50	.....	.....	.....	.....	
25	.....	L.....	16 11 57	.....	.....	.....	.....	
		M.....	16 18 50	.....	*200	.....	.....	
		F.....	16 28 40	.....	.....	.....	.....	
26	.....	P or L.	0 06 53	.....	.....	.....	.....	
		M.....	0 08 32	.....	*100	.....	.....	
		F.....	0 11 58	.....	.....	.....	.....	

* Trace amplitude.

No earthquakes were recorded at the following stations during October, 1921:

COLORADO. *Regis College*, Denver.

VERMONT. *U. S. Weather Bureau*, Northfield.

Reports for October, 1921, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.

ALASKA. *U. S. C. & G. S. Magnetic Observatory*, Sitka.

CALIFORNIA. *Theosophical University*, Point Loma.

HAWAII. *U. S. C. & G. S. Magnetic Observatory*, Honolulu.

MASSACHUSETTS. *Harvard University*, Cambridge.

NEW YORK. *Canisius College*, Buffalo.

TABLE 3.—*Late reports (instrumental)*.

NEW YORK. *Cornell University, Ithaca.*

1921.			H. m. s.	Sec.	μ	μ	Km.
July 8	.....	e.....	10 58 12	5	.....	.....	.....
		e.....	11 02 06	4	.....	.....	.....
		L.....	11 03 24	12	.....	.....	.....
		F.....	11 12 ..	.....	.....	.....	.....
Aug. 19	.....	e.....	8 40 18	6	.....	.....	.....
		F.....	8 49 ..	.....	.....	.....	.....
23	.....	eS.....	20 31 18	10	.....	.....	.....
		eL.....	20 38 ..	20	.....	.....	.....
		F.....	21 02 ..	.....	.....	.....	.....
Sept. 8	.....	e.....	19 40 36	4	.....	.....	.....
		e.....	19 41 30	5	.....	.....	.....
		e.....	19 43 35	8	.....	.....	.....
		F.....	19 49 ..	.....	.....	.....	.....

TABLE 3.—*Late reports (instrumental)*—Continued.

NEW YORK. *Cornell University, Ithaca*—Continued.

1921.			H. m. s.	Sec.	μ	μ	Km.
July 11	.....	P.....	4 21 44	3	.....	.....	.....
		PR1..	4 25 18	4	.....	.....	.....
		eL....	5 05 28	37	.....	.....	.....
		L.....	5 28 ..	28	.....	.....	.....
		F.....	6 10 ..	.....	.....	.....	.....
13	.....	e.....	3 02 ..	5	.....	.....	.....
		eL....	3 38 30	19	.....	.....	.....
		L.....	3 48 ..	20	.....	.....	.....
		F.....	4 01 ..	.....	.....	.....	.....
19	.....	L.....	4 41 ..	17	.....	.....	.....
		F.....	5 10 ..	.....	.....	.....	.....
20	.....	L.....	0 15 ..	21	.....	.....	.....
		F.....	0 53 ..	.....	.....	.....	.....

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

1921.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 5	.....	e.....	20 19 50	.....	.....	.....	.....	Heavy micros.
		eL_M?..	20 35 06	.....	.....	.....	.....	
		L_E....	20 42 38	21	.....	.....	.....	
		L_N....	20 47 09	13	.....	.....	.....	
		L_E....	20 48 18	22	.....	.....	.....	
		F.....	21 10 ..	.....	.....	.....	.....	
8	.....	e_N....	19 39 20	.....	.....	.....	.....	Difficult; EW does not show; heavy micros.
		F.....	20 *ca.*	.....	.....	.....	.....	
11	.....	eP_E...	4 21 33	.....	.....	.....	.....	
		iP_N...	4 21 35	.....	.....	.....	.....	
		S_E?....	4 32 37	.....	.....	.....	.....	
		S_N?....	4 32 47	.....	.....	.....	.....	
		eL....	4 51 06	26	.....	.....	.....	
		L_E....	5 13 ..	32	.....	.....	.....	
		L_N....	5 11 16	27	.....	.....	.....	
		L_E....	5 21 ..	38	.....	.....	.....	
		L_N....	5 30 ..	22	.....	.....	.....	
		F.....	6 50 ..	.....	.....	.....	.....	
13	.....	e_E....	2 55 24	.....	.....	.....	.....	
		e_N....	2 55 32	.....	.....	.....	.....	
		S?.....	3 01 31	.....	.....	.....	.....	
		eL....	3 09 48	.....	.....	.....	.....	
		F.....	3 45 ..	.....	.....	.....	.....	
13	.....	P?.....	4 30 37	.....	.....	.....	.....	Heavy micros.
		L_E....	4 42 21	16	.....	.....	.....	
		L_N....	4 42 07	.....	.....	.....	.....	
		F.....	5 10 ..	.....	.....	.....	.....	
19	.....	e?.....	23 45 31	.....	.....	.....	.....	Heavy micros.
		S_E?....	23 52 22	.....	.....	.....	.....	
		S_N?....	23 52 14	.....	.....	.....	.....	
20	.....	eL_M?..	0 02 12	.....	.....	.....	.....	
		L_E....	0 13 38	22	.....	.....	.....	
		F.....	0 35 ..	.....	.....	.....	.....	

Chart I. Hydrographs of Several Principal Rivers. October, 1921.

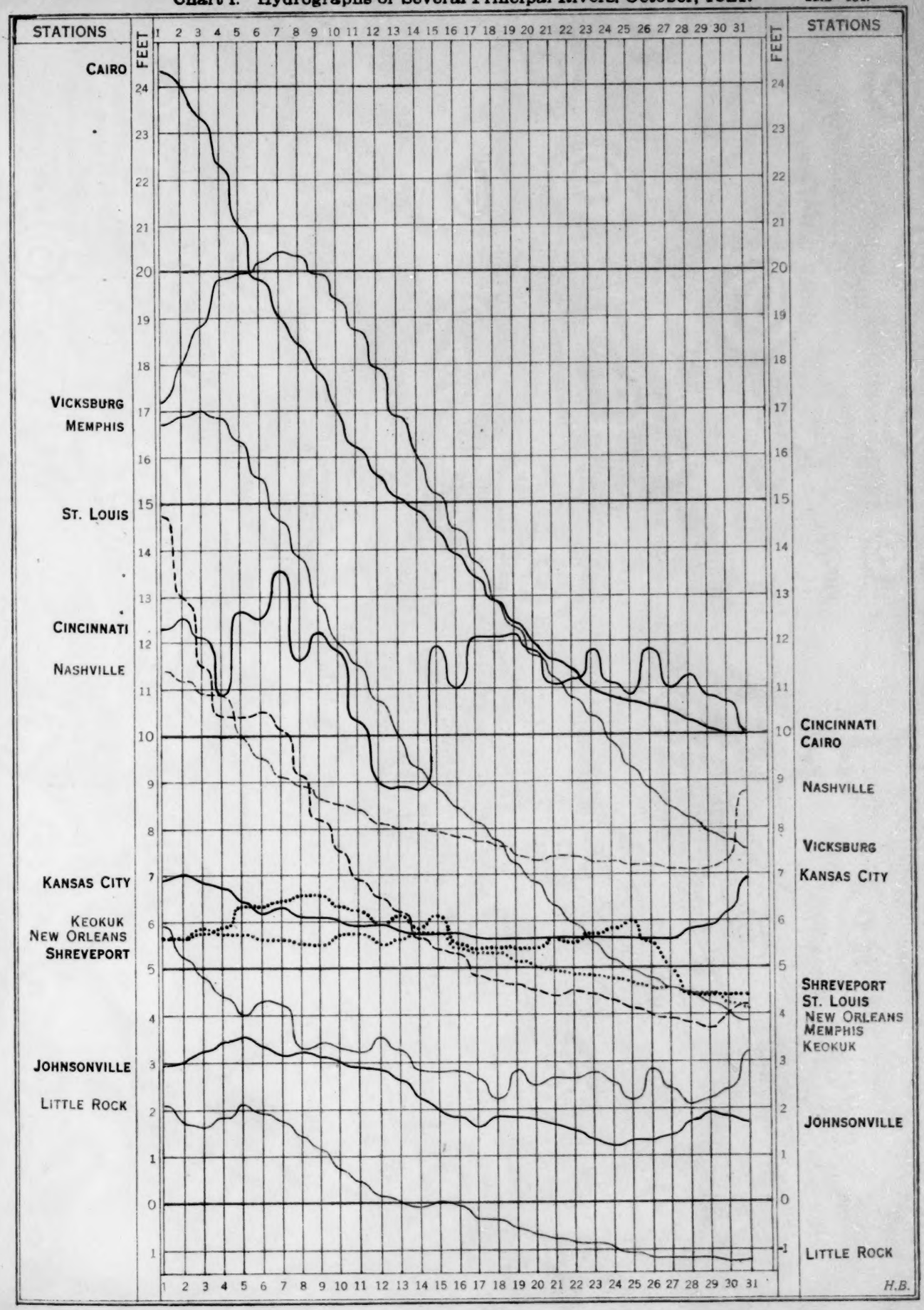


Chart II. Tracks of Centers of High Areas, October, 1921.

(Plotted by Wilfred P. Day.)

Chart III. Tracks of Centers of Low Areas, October, 1921.

(Plotted by Wilfred P. Day.)

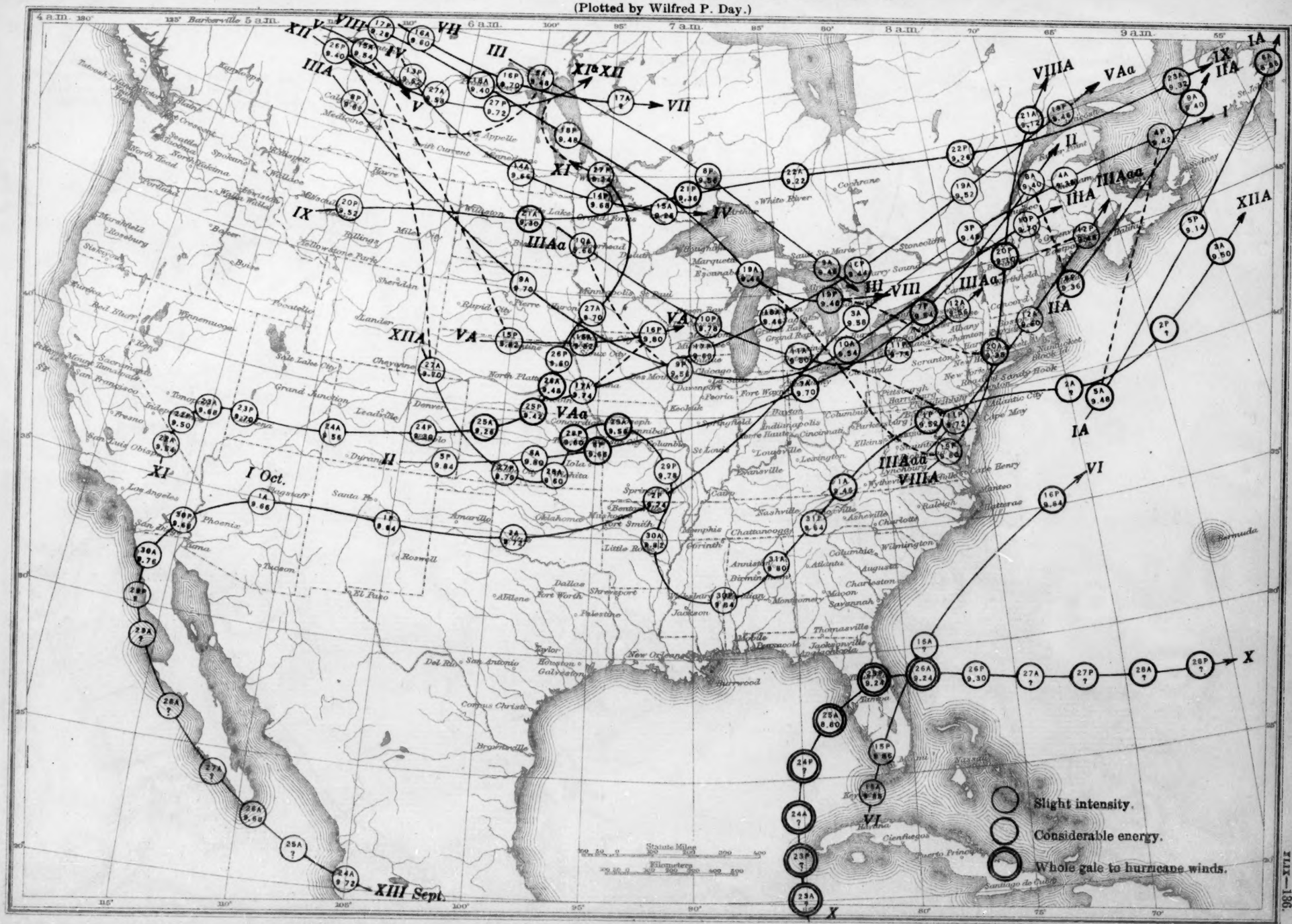


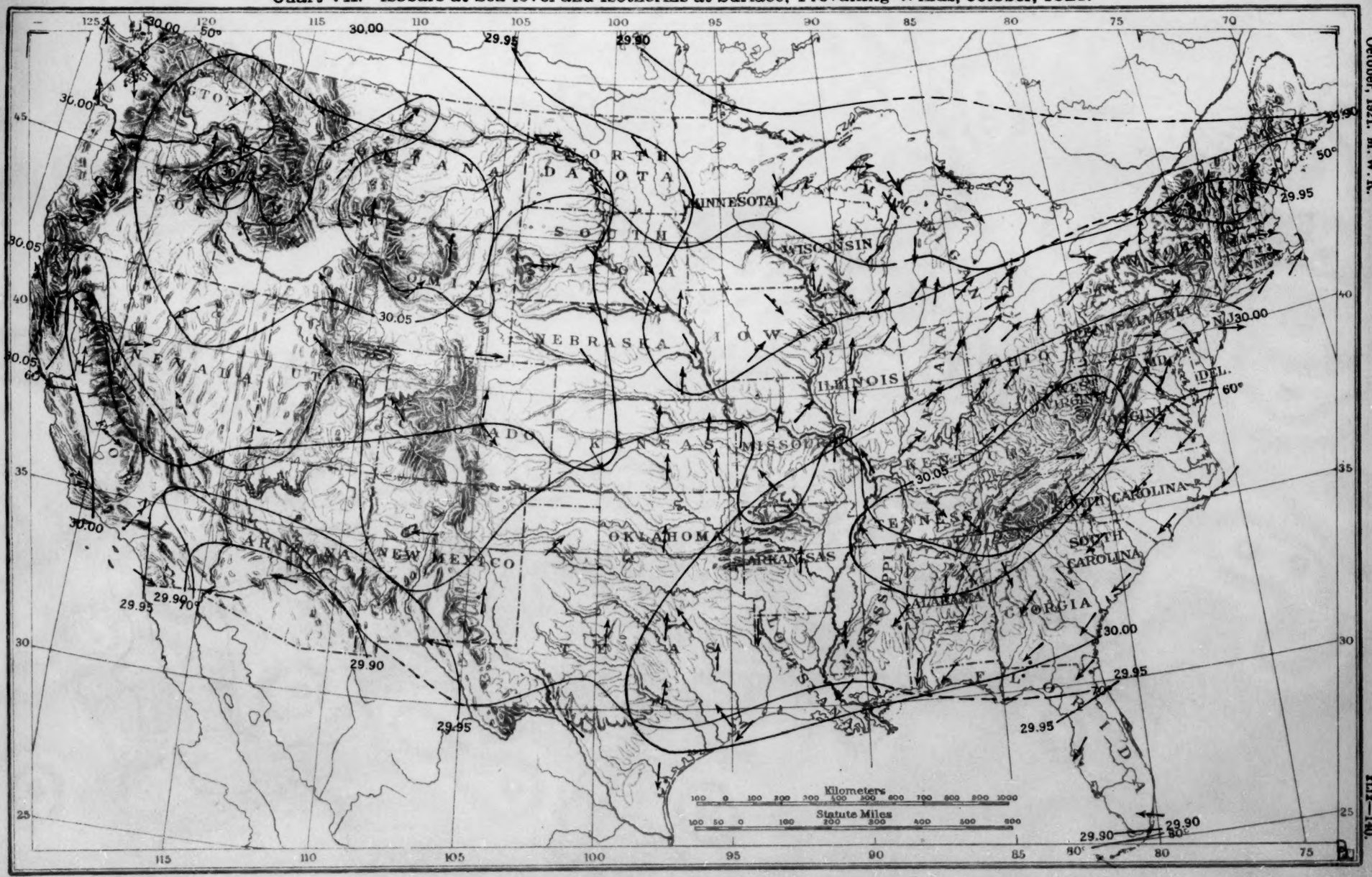
Chart IV. Departure (°F.) of the Mean Temperature from the Normal, October, 1921.

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart V. Total Precipitation, Inches, October, 1921.

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, October, 1921.

Chart VII. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, October, 1921.



October, 1921. M. W. R.

111—140.

Chart VIII. Total Snowfall, Inches, October, 1921.

Chart IX. Weather Map of North Atlantic Ocean, October 24, 1921.

Chart IX. Weather Map of North Atlantic Ocean, October 24, 1921.

(Plotted by F. A. Young.)

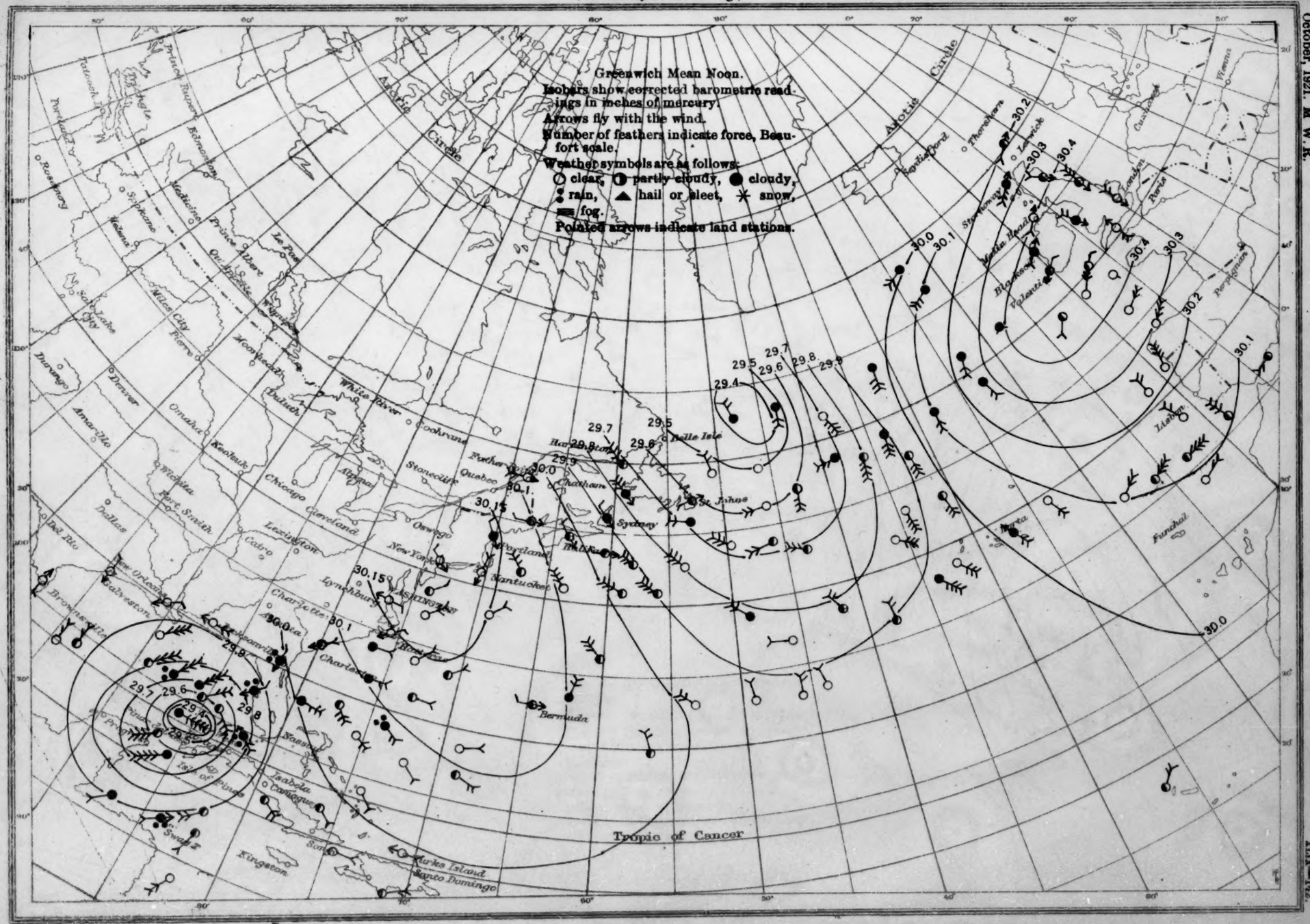


Chart X. Weather Map of North Atlantic Ocean, October 25, 1921.

(Plotted by F. A. Young.)

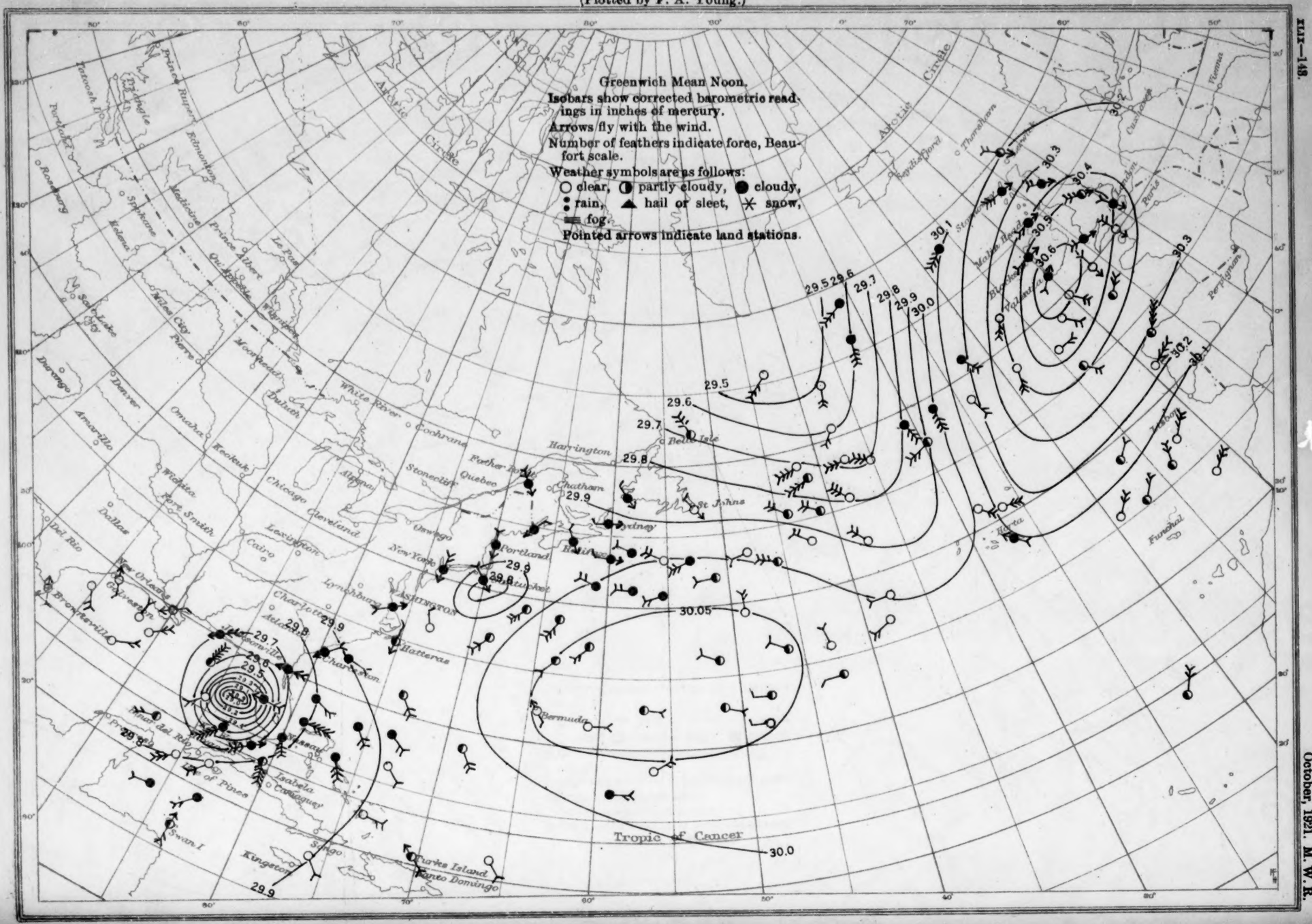


Chart XI. Weather Map of North Atlantic Ocean, October 26, 1921.

Chart XI. Weather Map of North Atlantic Ocean, October 26, 1921.

(Plotted by F. A. Young.)

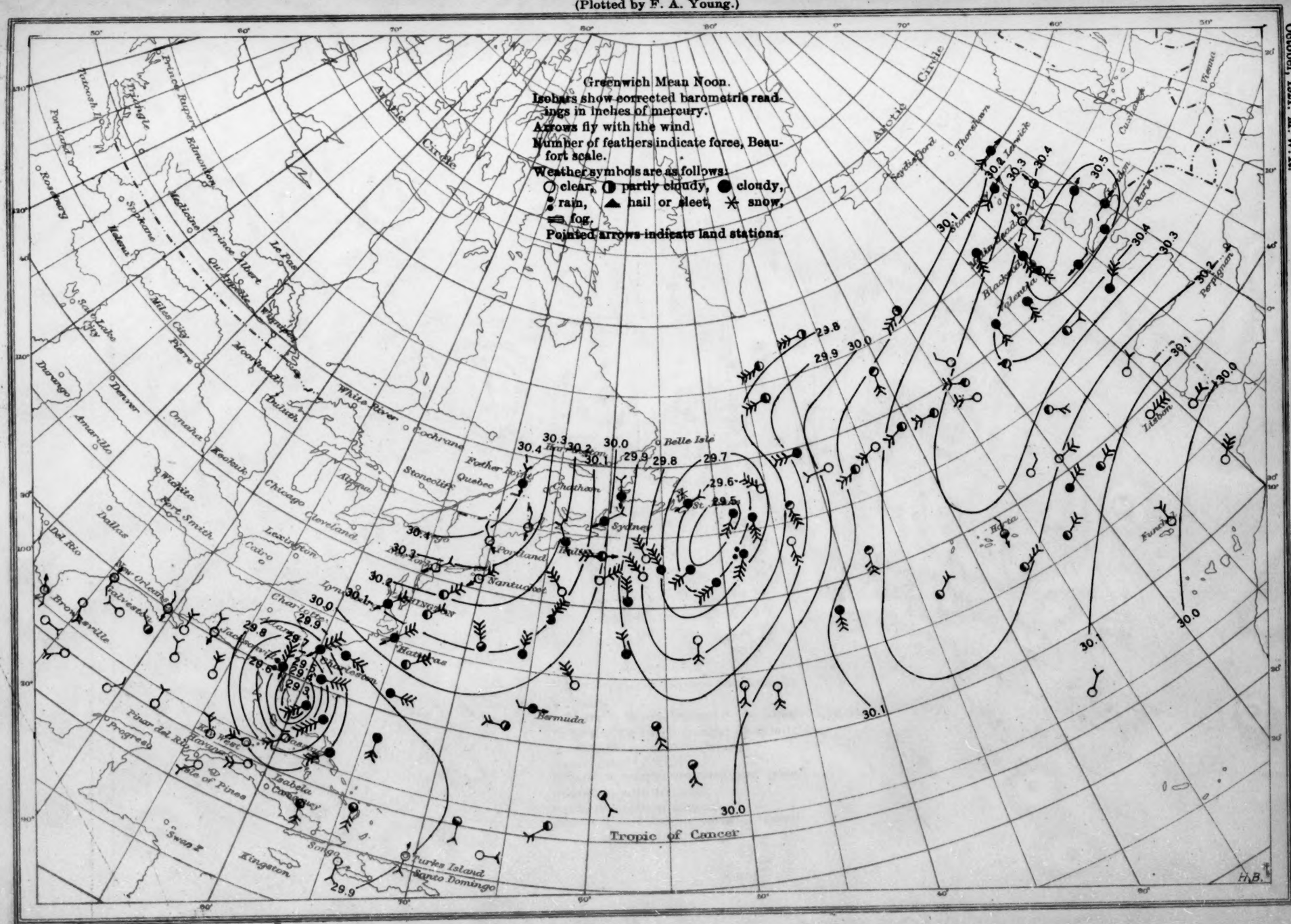


Chart XII. Weather Map of North Atlantic Ocean, October 27, 1921

(Plotted by F. A. Young.)

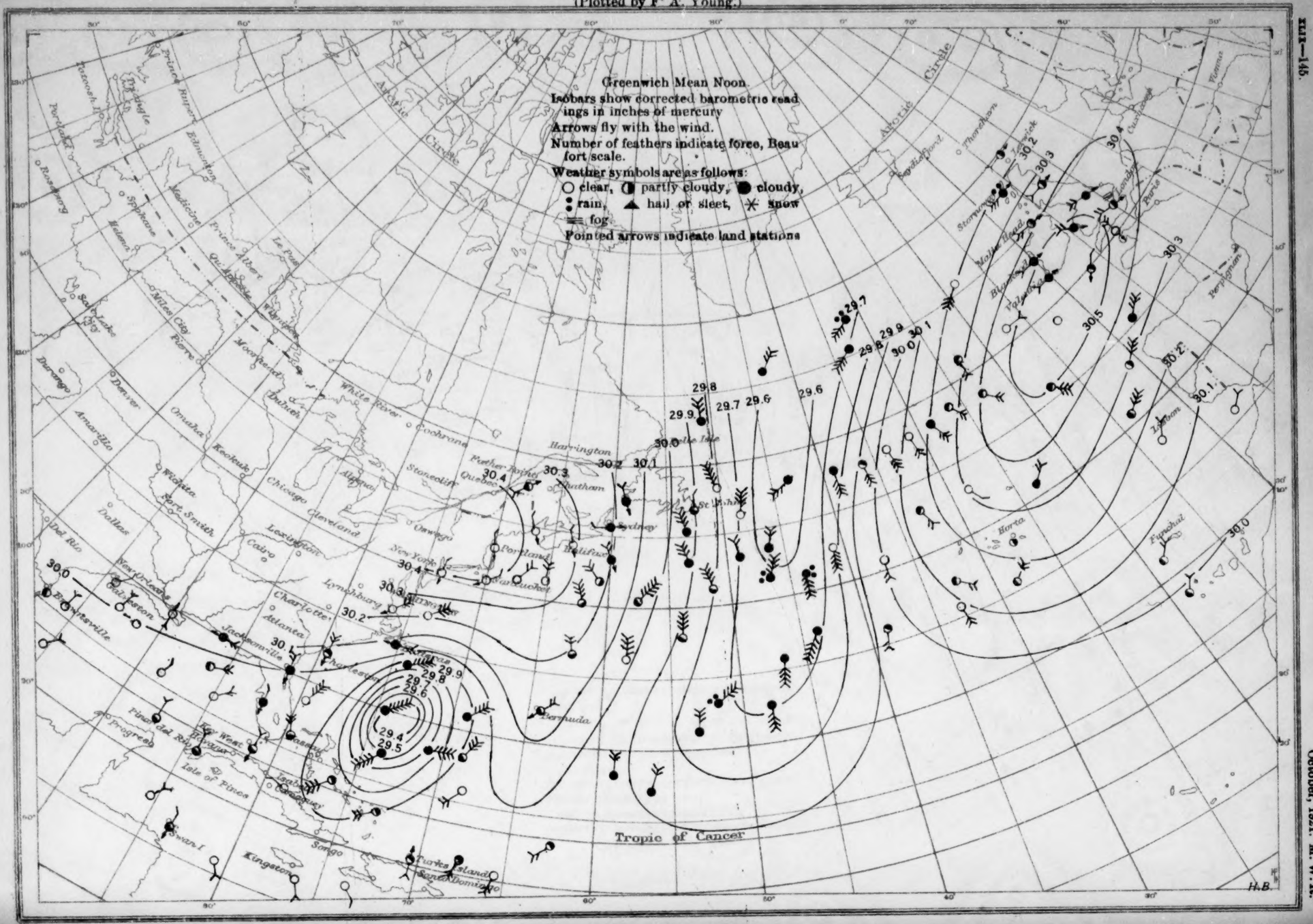

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow
fog
Pointed arrows indicate land stations
Tropic of Cancer
H.B.

Chart XIII. Weather Map of North Atlantic Ocean, October 28, 1921.

Chart XIII. Weather Map of North Atlantic Ocean, October 28, 1921.

(Plotted by F. A. Young.)

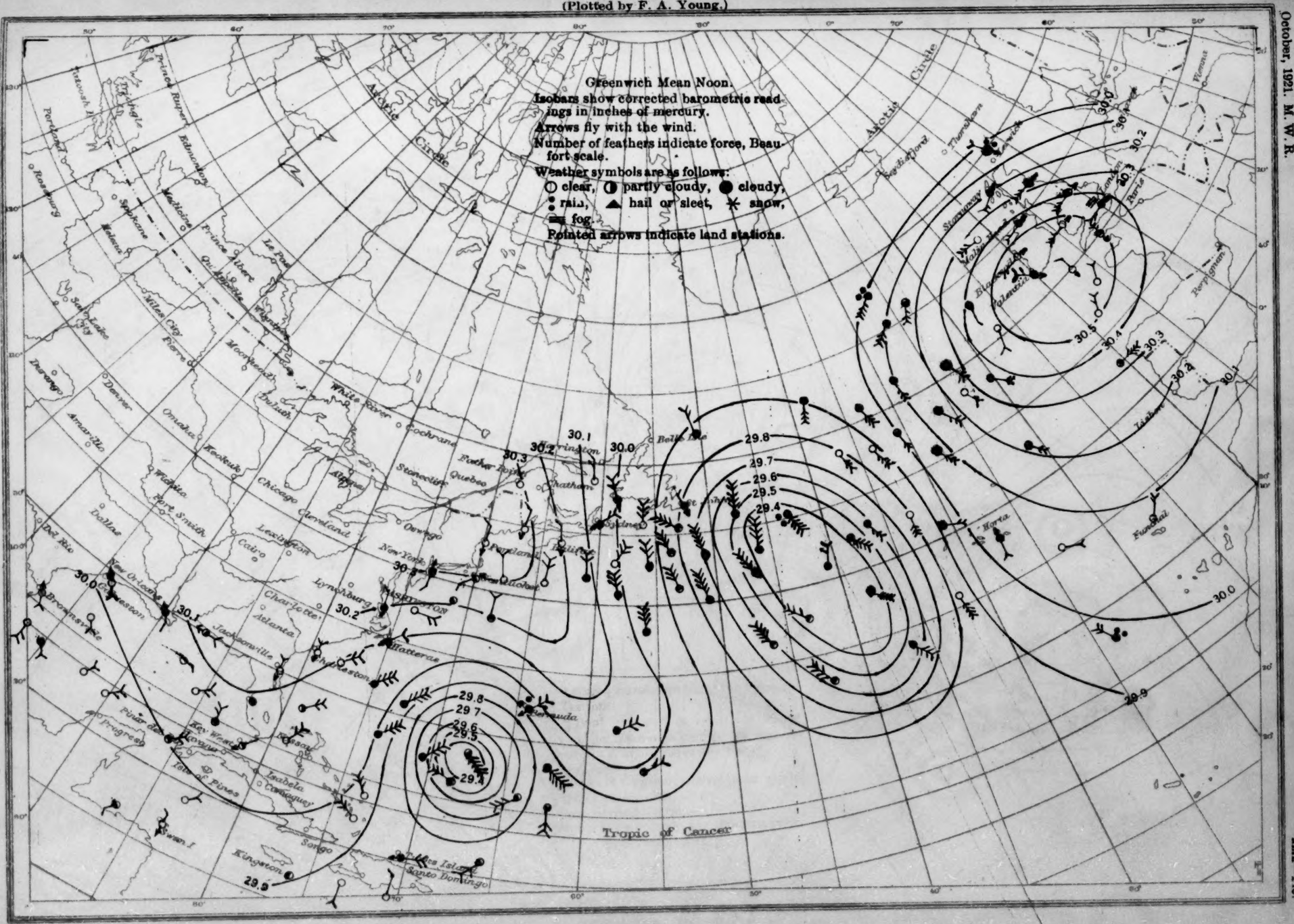


Chart XIV. Weather Map of North Atlantic Ocean, October 29, 1921.

(Plotted by F. A. Young.)

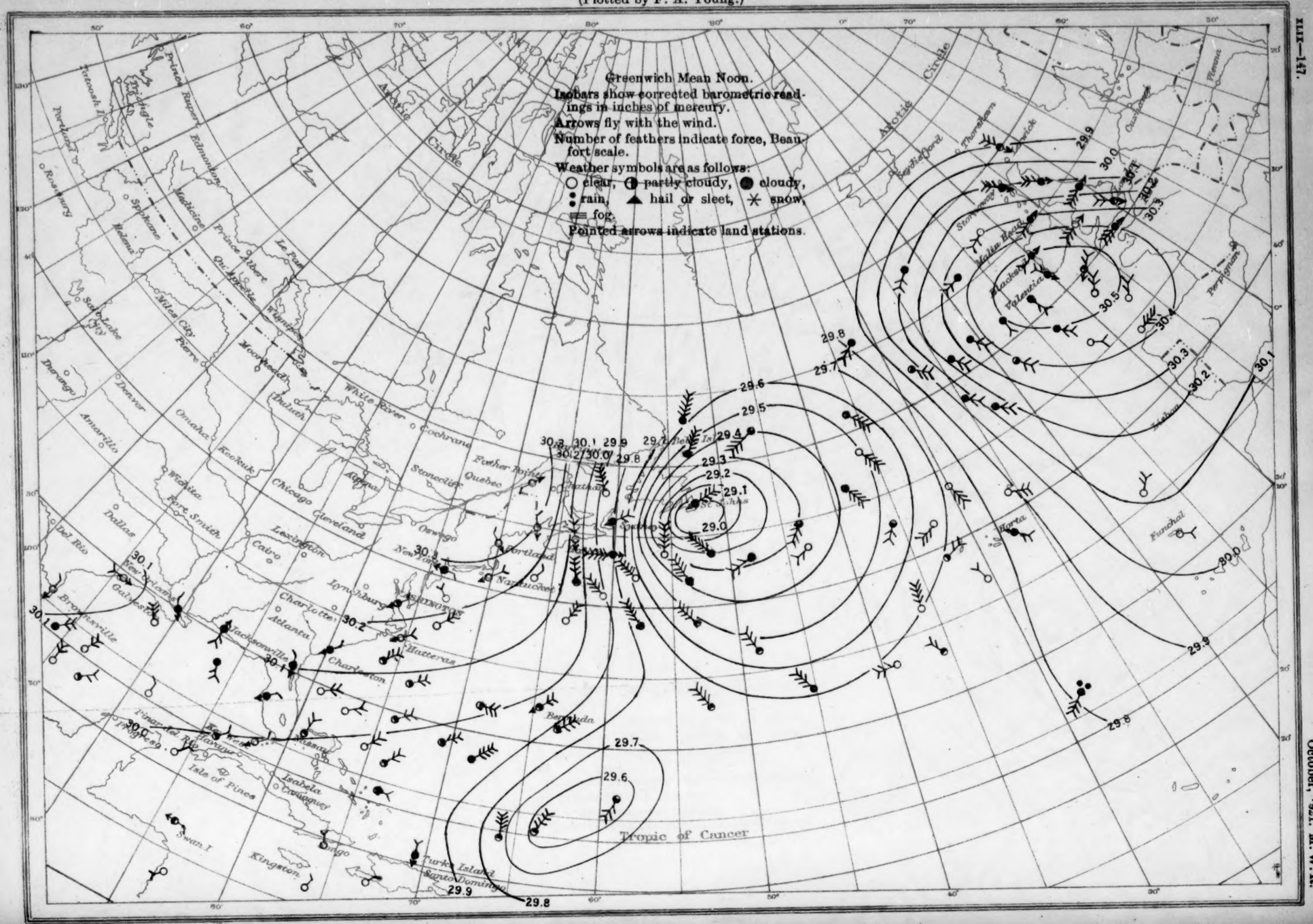

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Arctic Circle
Tropic of Cancer
Bermuda
Turks Island
Santo Domingo
Kingston
Isle of Pines
Swan I.
Key West
Havana
Jacksonville
Charleston
Hatteras
Atlanta
Charlotte
Lynchburg
Cairo
Lexington
Cleveland
Chicago
Omaha
Denver
Amarillo
Dallas
Del Rio
Brownsville
Galveston
New Orleans
Fort Smith
Wichita
Kansas City
Pierre
Miles City
Medicine Hat
Edmonton
Prince Albert
Prince Rupert
Victoria
Portland
Roseburg
Spokane
Salt Lake City
Durango
Moosonee
Duluth
White River
Cochrane
Father Point
Quebec
Stonecliffe
Ottawa
Toronto
Parry Sd.
Port Arthur
Winnipeg
Le Pas
Prince Albert
Nantucket
New York
Portland
Boston
Halifax
Yarmouth
Sydney
Charlottetown
Father Point
Quebec
Ottawa
Toronto
Port Arthur
Winnipeg
Le Pas
Prince Albert
Edmonton
Medicine Hat
Prince Rupert
Victoria
Portland
Roseburg
Spokane
Salt Lake City
Durango
Denver
Amarillo
Dallas
Del Rio
Brownsville
Galveston
New Orleans
Fort Smith
Wichita
Kansas City
Pierre
Miles City
Moosonee
Duluth
White River
Cochrane
Stonecliffe
Quebec
Ottawa
Toronto
Parry Sd.

Chart XV. Weather Map of North Atlantic Ocean, October 30, 1921.

(Plotted by F. A. Young.)

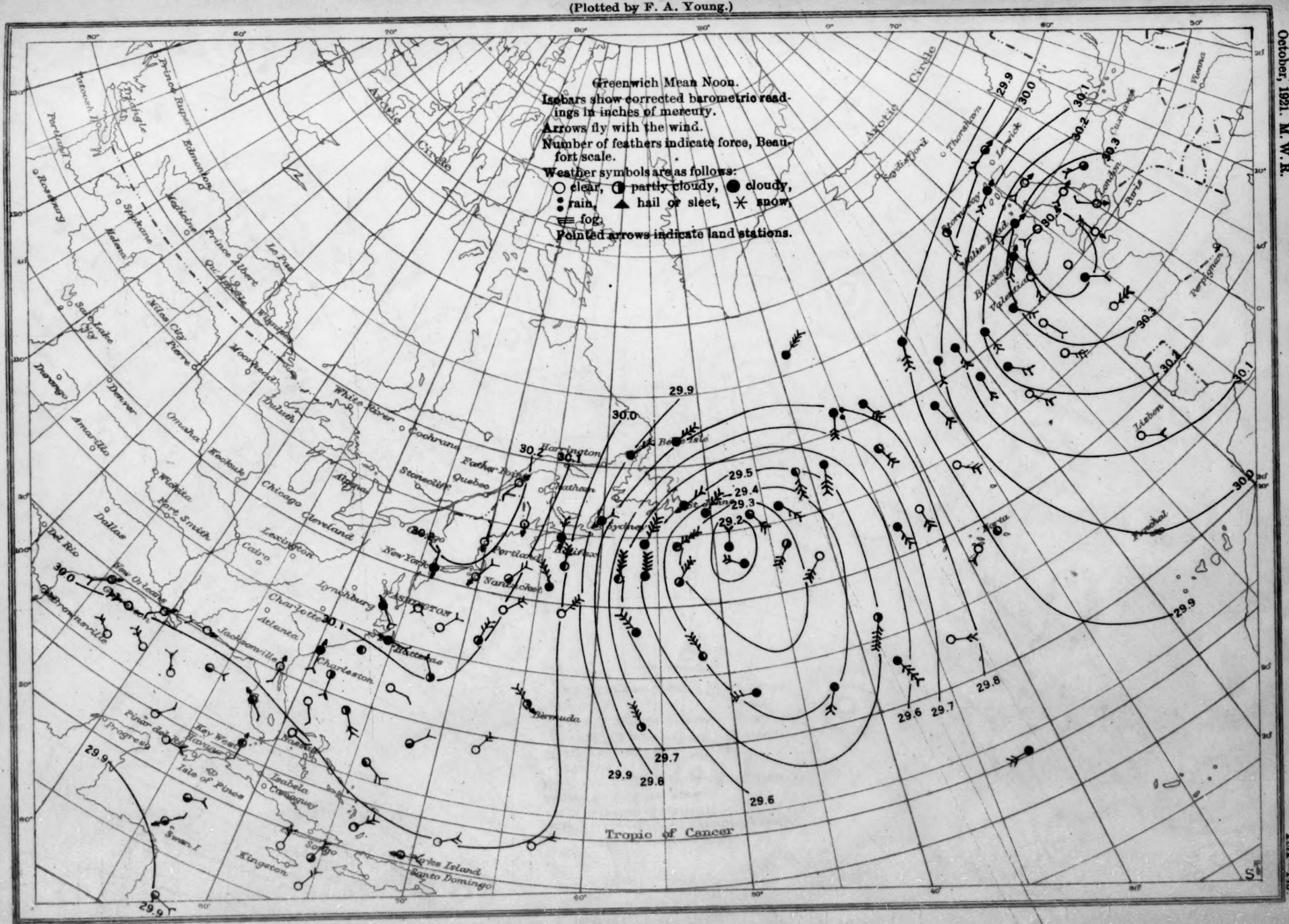
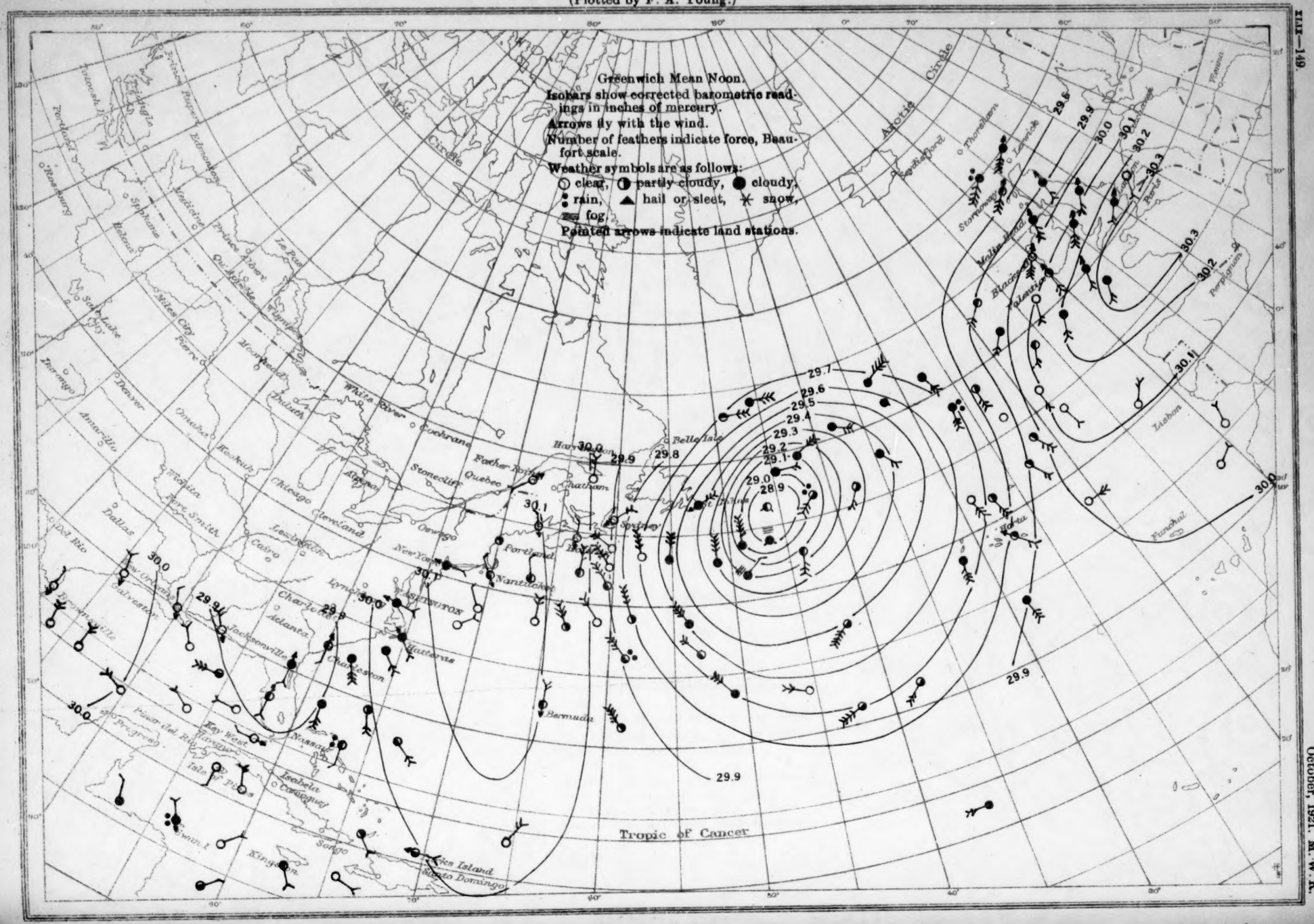


Chart XVI. Weather Map of North Atlantic Ocean, October 31, 1921.

(Plotted by F. A. Young.)



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OCTOBER, 1921.

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CORRIGENDA.

REVIEW, October, 1920:
Page 619, last line, pressure departure recorded "−.04" *should be* "+04".

† In marine separate.